A

PRACTICAL TREATISE

ON

DISEASES OF THE EYE.

BY

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WITH ONE HUNDRED AND TWENTY-FOUR ILLUSTRATIONS.

EDITED WITH ADDITIONS AND TEST-TYPES BY JOHN GREEN, M.D.

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PREFACE.

My aim in the composition of the following pages has been to place before the profession, in a concise and readable form, a general view of the present state of knowledge with regard to the nature and treatment of the more important diseases of the eye. I have not thought it necessary to dwell minutely upon maladies of rare occurrence, or upon details which are interesting only to specialists; neither have I attempted to achieve that kind of completeness which is produced by undigested compilation. The book embodies the substance of my lectures at St. George's Hospital, and contains but slight reference to modes of practice of which I am unable to speak from experience.

With perhaps three or four exceptions, the illustrations are original. The woodcuts scattered among the text, when they are not figures of instruments, are mostly diagrams, such as would be sketched upon the blackboard in lecturing, for the purpose of shortening verbal descriptions. The lithographed plates[1] are from drawings by my son, Mr. W. J. B. Carter; and the eyes represented in Plates III and IV[2] are all of them faithful portraits from life. No representations of the fundus of the eye have been introduced; because the cost of chromo-lithographs of sufficient accuracy and delicacy would have been greatly in excess of any advantages which could be derived from them.

Wimpole Street, W., July, 1875.

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[1] [Figs. 1–4, 70, and 73–82, of this edition.]

[2] [Figs. 8, 70, and 73–82, of this edition.]

EDITOR'S PREFACE.

In preparing the American edition of Mr. Carter's work for the press, such typographical errors as have been noticed, together with a few others which appeared to be the result of oversight in proofreading, have been corrected without especially designating them. A few short passages, also, disconnected from the immediate subject-matter or devoid of interest to American readers, have been omitted. In reproducing the woodcuts of the English edition, a few inaccuracies in drawing have been corrected, two substitutions have been made, and eighteen additional cuts have been introduced. The lithographed plates, also, have been reproduced as woodcuts. All notes and additions to the text by the editor are included within brackets [—]. A sheet of test-letters, substantially as approved by the author (page 59), is given at the end of the volume.

St. Louis, June, 1876.

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CHAPTER I.

ANATOMY AND PHYSIOLOGY.

A TREATISE which professes to embrace the most important of the various matters that fall under the notice of an ophthalmic surgeon seems to require, almost as a matter of course, some introductory account of the anatomy and physiology of the eyes and of their appendages, and some notice of considerations which are common to nearly every case of ocular disease or of visual disturbance. It would be foreign to my purpose to describe all the details of structure which may be found fully set forth in anatomical text-books; and I have to speak of anatomy and physiology chiefly in a surgical sense, or as they bear upon questions which constantly arise in practice. Some topics of this kind will be most appropriately discussed when I come to write of particular diseases; but there are others which may be regarded as prefatory, and to which, when they have once been dealt with, it will not be necessary to return.

The eye is an approximately spherical organ, placed in such a position as to look out of the open base of the orbital cavity, resting upon a cushion of fat, moved in every direction about a centre by its muscles, communicating with the brain through the medium of the optic nerve, and with the membranes of the brain by direct vascular continuity, and protected against external harm not only by the prominent orbital margin, but also by the eyelids and by the cilia which fringe them. Its exposed surface is covered by a delicate mucous membrane, the conjunctiva, which is reflected to line the eyelids, and is continuous with that of the nasal cavities through the lacrymal canals, and with the common integument at the margin of the palpebral fissure. The conjunctiva is moistened, not only by the secretion of its own glands, but also by that of the lacrymal gland, which is lodged in the upper and outer angle of the orbit, and sends numerous ducts to open upon the in-

ternal surface of the outer part of the upper lid. [The ducts of the lacrymal gland open into the conjunctival sac, a very little distance in front of the fornix. Merkel, *Graefe und Saemisch; Handbuch der gesammten Augenheilkunde*, I, I, page 89.] The conjoined secretions, after passing over the conjunctiva, are received by the two puncta lacrymalia at the inner canthus, and are conveyed along the corresponding canaliculi, through the lacrymal sac and nasal duct, into the nose.

The globe of the eye, or eyeball proper, is composed of a protective envelope or sclerotic coat, the anterior transparent portion of which is called the cornea;[1] of a vascular membrane or choroid, with which an anterior perforated muscular diaphragm, the iris, is continuous through the intermediation of the ciliary body; of a nervous membrane or retina, for the reception and transmission of visual impressions; and of certain contained humors, or media, the aqueous humor, the crystalline lens, and the vitreous body, which not only, by their refracting properties, cast defined optical images upon the retina, but also preserve the shape and tension of the entire organ. In order to facilitate description, it is customary to apply to the "globe" other terms which in like manner have been borrowed from geography. The geometrical summit or centre of the cornea is called the "anterior pole" of the eyeball; and the geometrical centre of the fundus is, in like manner, the "posterior pole." An imaginary line from pole to pole, passing through the centre, is the "axis;" and an imaginary vertical plane, passing through the centre perpendicular to the axis, is the "equator," and divides the eye into an anterior and posterior hemisphere. Imaginary planes coincident with the axis are called "meridians;" and of these there may of course be any number; but the vertical meridian, which divides the eye into a nasal and a temporal hemisphere, and the horizontal meridian, which divides it into a superior and an inferior hemisphere, are those chiefly mentioned by writers. We speak in the same sense of the anterior and the posterior pole of the crystalline lens, and also of its equator, or margin; and we divide the surfaces of the lens and of the cornea into "quadrants;" saying, for example, of an ulcer, or a foreign body, that it is situated in the upper and outer quadrant of the cornea, that is, manifestly, in a space bounded below by the horizontal, and on the inner side by the vertical, meridian.

The sclerotic, or sclera (which is indicated by the letter S, Figs. 1 and 2), forms the posterior four-fifths [about nine-tenths] of the external tunic. It is a dense fibrous membrane, of very firm texture, and of glistening whiteness. At the posterior part, where it is perforated to permit the passage of the optic nerve-fibres and the retinal vessels, and where it receives and is reinforced by the sheaths of the optic nerve, it is usually about a millimetre in thickness;

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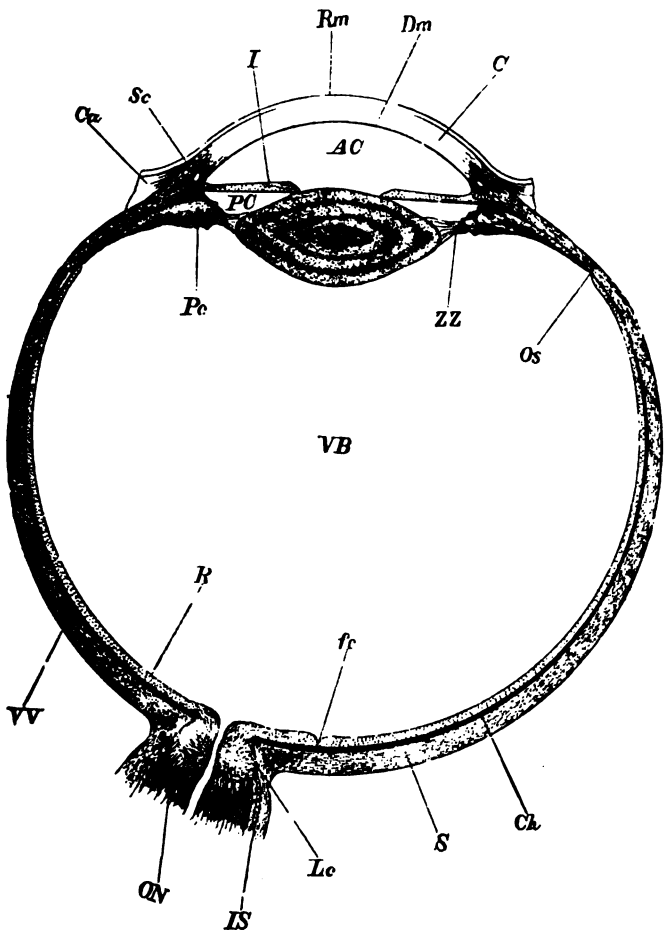
[1] [Only the posterior non-transparent portion of the *tunica externa* is called the sclerotic or sclera.]

and it gradually thins off anteriorly until, near the cornea, it is again reinforced by the tendons of the recti muscles.

FIG. 1.



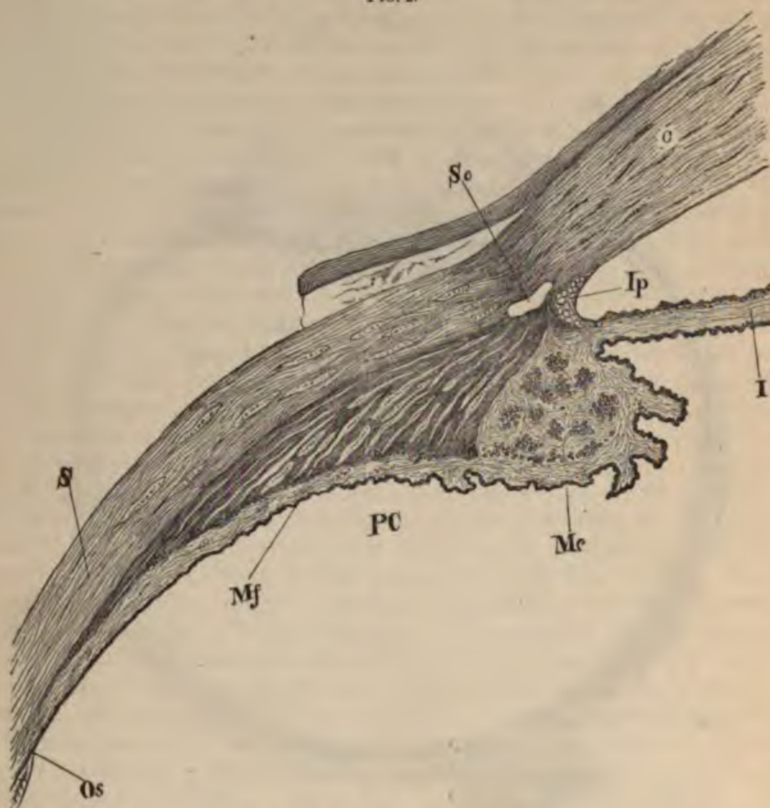
Horizontal Section of the Right Eye [lower half].

S, sclerotic; C, cornea; L, crystalline lens; I, iris; Ch, choroid; R, retina; AC, anterior chamber; PC, posterior chamber; Pc, ciliary process; Os, ora serrata; ZZ, zonule of Zinn; Dm, Descemet's membrane; Rm, Reichert's membrane; Sc, Schlemm's canal; Ca, conjunctiva; VB, vitreous body; fc, fovea centralis; VV, vena vorticosa; Lc, lamina cribrosa; ON, optic nerve; IS, intervaginal space. [Copied, with a little variation, from Merkel.]

The perforation for the optic nerve-fibres, which is called the sclerotic foramen, is about two millimetres [1.4 mm., Merkel, *op. cit.*, I, I, page 15; 1.5 mm., Schwalbe, *op. cit.*, I, I, page 347] in diameter. It is situated nearly on [a little below] the horizontal meridian of the eyeball, about four millimetres to the nasal side of the posterior pole, and is partially closed, at the level of the external surface of the sclera, by a fine web of white fibrous

tissue, the lamina cribrosa (Lc, Fig. 1), which suffers the nerve-fibres and vessels to pass through the sieve-like openings in its structure. At its anterior portion the sclera is somewhat con-

FIG. 2.



Enlarged Section of Ciliary Region.

S, sclerotic; C, cornea; I, iris; Ip, ligamentum pectinatum; Sc, Schlemm's canal; PC, ciliary process; Os, ora serrata; Mf, meridional fibres of ciliary muscle; Mc, circular fibres of ciliary muscle. [After drawings by Merkel and Iwanoff. The drawing of the ciliary muscle is from an illustration, by Iwanoff, of a hypermetropic eye; the circular fibres, Mc, are ordinarily much less developed than would appear from this figure.]

tracted or drawn in, so as to form a circular narrowing or depression (sulcus scleræ) around the cornea; and, just in front of this, its substance is traversed, near its internal surface, by a circular channel, known as Schlemm's canal (Sc, Figs. 1 and 2), which contains and protects an intricate plexus of veins. The sclera is covered in front by the conjunctiva of the globe; and, as seen through this membrane, constitutes the white of the eye. In young infants, however, it presents a bluish aspect, having then a translucency which permits the dark color of the choroid beneath to be in some degree perceptible; and in advancing life its whiteness is apt to be obscured by a yellow tinge derived from adipose deposit in the subconjunctival tissue, or possibly in the sclera itself.

The cornea (C, Figs. 1 and 2), the anterior fifth [tenth] of the external tunic, is a dense membrane of seemingly absolute transparency, and is so curved as to form a portion of a smaller spheroid (or rather ellipsoid) than the sclera itself, into which it is implanted somewhat after the fashion of a watch-glass into its setting, the opaque scleral tissue advancing further anteriorly than posteriorly, and also advancing further above and below than laterally; so that the cornea, which appears circular when seen from within, is elliptical in its outer aspect, and has a vertical diameter which is usually about half a millimetre less than the horizontal. Its general thickness is about a millimetre; but it is usually two-tenths of a millimetre greater at the margin than in the centre, so that the anterior and posterior surfaces are not parallel. [Throughout the whole central region of the cornea its two surfaces are parallel; it is only near its periphery that it is somewhat thicker, 9 mm. in its central region, 1.1 mm. near its periphery. Merkel, *op. cit.*, I, I, page 45.] It has a laminated arrangement, the laminæ being composed of delicate fibres, and being so arranged as to inclose numerous irregular spaces or cavities, which contain nucleated cells, and which communicate freely with each other, so as to form what may be described as a system of channels for the circulation of liquor sanguinis. The proper substance of the cornea is inclosed within two structureless membranes, usually called after their discoverers;—the anterior, or external (Rm, Fig 1), is known as Reichert's [described independently by Mr. Bowman, and very often called *Bowman's*] membrane, the posterior, or internal (Dm, Fig. 1), as the membrane of Descemet; the latter, as will be seen hereafter, often playing a very important part in cases of corneal ulceration. Each of these membranes is covered by an epithelium, which, on the external one, is continued from the epithelium of the conjunctiva. The cornea, as a whole, therefore, is formed of five distinct layers: first, the external epithelium; secondly, Reichert's membrane; thirdly, the proper substance; fourthly the membrane of Descemet; and fifthly, the internal epithelium. The healthy cornea contains no bloodvessels, although they often become developed during disease; but it is very richly supplied with nerves, which ramify not only in the deeper layers of the anterior epithelium, but also in the proper corneal substance, anastomosing freely, and forming a network or plexus of great fineness and intricacy.

The outer surface of the cornea possesses a high degree of polish and smoothness, and returns, as a convex mirror, a clearly defined, diminished, erect image of any object in front of it. The transparency of the membrane to transmitted light is [nearly] perfect, so that it allows every detail of the lustrous surface of the iris to be seen; but, when examined by focal or oblique illumination, it reveals something of its fibrous and cellular structure by reflecting the different elements of white light irregularly, so that the path of the beam is rendered visible against particles, as when light passes through water or uncleansed air. In the decline of

life, moreover, the transparency of the peripheral portion is often destroyed by a circle of fatty degeneration, the well-known arcus senilis, which usually commences as two delicate curved lines, one at the upper and one at the lower part, which gradually increase in length until they unite, and at the same time increase in thickness also, so that the circle which they form may ultimately attain a considerable breadth, although it never, as far as I am aware, encroaches upon the pupillary space. Neither does it ever extend quite to the corneo-scleral junction, but is always surrounded by a zone of transparent tissue, so that it may be readily distinguished from the annular marginal opacity which is sometimes left behind by inflammation, and which is always directly continuous with the conjunctiva. Arcus does not usually appear until the age of fifty, or even sixty; but I have more than once seen it when the adjective "senilis" would have been a wholly inappropriate description. I remember especially a well-marked arcus in each eye of a gentleman only twenty-five years of age, of sound constitution and robust or even athletic frame, and with large well-developed eyes with dark blue irides. He consulted me on account of the conspicuousness of the circles, but I could not discover that he displayed any tendency to fatty degeneration in any other organ of his body.

The choroid, or vascular tunic of the eye (Ch, Fig. 1), does not extend quite so far forward as the sclerotic, but lines the posterior three-fifths [two-thirds, Merkel, *op. cit.*, I, I, p. 24] of the globe, and is merged anteriorly in the circle of ciliary processes. It is in immediate contact with the inner surface of the sclerotic, to which it is united by a few fibres of lax connective tissue. Like the sclerotic, it is perforated for the passage of the optic nerve and retinal vessels, but the perforation is very slightly smaller than that of the sclerotic, over which it is superimposed, and is bounded and strengthened by a circle of connective-tissue fibres, some of which send out processes that pass between the nerve bundles and are lost in the lamina cribrosa. The choroid consists almost entirely of bloodvessels, supported by a delicate web of connective tissue, but is abundantly supplied with nerves, and contains also bundles of unstriped muscular fibre. The interstices of the stroma are filled by cells containing dark-brown pigment, which, together with the blood in the vessels, gives to the membrane a reddish-brown or chocolate color. The quantity of pigment varies much in different individuals. It is most abundant in dark people and in the dark races, is found only in small quantity in very fair persons, and is altogether wanting in albinos. For convenience of description, the choroid is divided into layers; but this division is arbitrary, and has been carried to an unnecessary degree of refinement by many writers. Two layers may, however, be recognized in practice; the external, containing large vessels and abundant pigment, and the internal containing small vessels or capillaries, and comparatively little pigment. The most conspicuous vessels of the external layer are the stellate clusters

of veins known as the venæ vorticosæ. These clusters are usually four, sometimes five or six, in number; and each one is composed of ten or twelve veins which converge to a common central trunk. The convergent veins are so placed that, when seen only in a small part of their course, they appear nearly parallel to those contiguous to them; and the interspaces are usually filled up by loose cells loaded with pigment. Hence, when seen from within, by the ophthalmoscope, the choroid presents a striped appearance—the stripes being due to the alternation of nearly parallel veins, through which the color of the blood is visible, with linear interspaces rendered dark by pigment. The choroidal veins are not visible with the ophthalmoscope under ordinary conditions, but when they become visible they can be immediately recognized by their approach to a parallel arrangement. The central trunks of the venæ vorticosæ pass out through the sclera by very oblique channels (VV, Fig. 1) directed from before backwards, and situated posteriorly to the equator, about the junction of the middle with the posterior third of the eyeball. The inner vascular layer of the choroid, often called the chorio-capillaris, contains fine or capillary vessels only, and is separated from the retina by a smooth and homogeneous basement membrane.

A short distance in front of the equator, and of the anterior boundaries of the venæ vorticosæ, the choroid no longer remains in contact with the sclerotic, but begins to be elevated from it into a regular circle of plaits or folds, usually seventy in number, and known as the ciliary processes (Pc, Fig. 1 and PC, Fig. 2). These processes are arranged radially around the posterior aspect of the margin of the iris; and, as shown in the figures, they increase in size from behind forwards, and terminate anteriorly in rounded extremities. Each process is covered, and also the sulcus between each two processes, by the choroid, but the mass of each process is formed by the ciliary muscle. The processes, taken collectively, constitute the ciliary body; and the part of the eye in which they are situated, and in which the several tunics are united more intimately than elsewhere, is called the ciliary region. This region is very abundantly supplied with nerves and bloodvessels, and, as will be seen hereafter, is one of great surgical importance. [The ciliary processes consist of the choroidal stroma and bloodvessels developed in it. Merkel, *op. cit.*, I, I, p. 27.]

The ciliary muscle, muscle of accommodation, or tensor of the choroid, consists of unstriped fibres, of which the anterior (Mc, Fig. 2) are arranged in a circle, while the posterior, or meridional, radiate in the direction of the processes themselves. These meridional fibres (Mf, Fig. 2) have their origin in a circular tendon, situated at the corneo-scleral junction, immediately on the inner side of Schlemm's canal, and separated from Descemet's membrane by a little connective tissue. The external fibres pursue a course parallel to the inner surface of the sclera, and lose themselves in the choroid, forming connections with the muscular tissue which is dispersed through its stroma. The internal meridional fibres turn somewhat away from the sclerotic towards the

axis of the eyeball, and form an intricate network, which fills up much of each process. The circular fibres, seen in section at Mc, Fig. 2, pass through and occupy the anterior rounded part of each process. The muscle as a whole, is known to effect those alterations in the curvature of the lens by which the eye is adjusted, or "accommodated," for vision at different distances, but there is much difference of opinion concerning the precise mode of its operation. [This is the commonly accepted view and rests on the authority of a great name, Helmholtz. Much may, nevertheless, be said in support of the theory of John Hunter and Dr. Young, that the lens is itself a contractile organ, capable of changing its form under nervous stimulus.] The development of its different parts varies greatly in eyes of different shape; the circular fibres preponderating in eyes with a short axis, the meridional in those with a long axis; a variation which corresponds with a functional difference of great importance, to which further reference will be made in a subsequent chapter.

The anterior portion of the vascular tunic, the iris, is a circular, vertical curtain or screen (I, Figs. 1 and 2), continuous posteriorly by its marginal attachment with the anterior borders of the ciliary processes, and anteriorly, by the ligamentum pectinatum (Ip, Fig. 2), with Descemet's membrane. These attachments are also called the "pillars" of the iris, and they carry back its origin a little behind the margin of the transparent cornea to the front portion of the ciliary body. The iris is perforated by a circular aperture, the pupil, for the transmission of light into the eye. The size of this aperture is constantly varying, in response to variations in the quantity of light which falls upon it [also in changes of accommodative adjustment], and its position is not quite central in the iris, but a little below the centre, and towards the nasal side. The iris resembles the choroid in general structure, but its more abundant muscular fibres are arranged, some in a circle around the pupil, others in lines radiating from the pupillary to the ciliary margin, so as to form a sphincter and a dilator of the opening. It is richly supplied with bloodvessels and nerves; and its arteries form two special circles of anastomosing vessels, one, the greater arterial circle of the iris, near the ciliary, the other, the lesser arterial circle, near the pupillary margin. The posterior surface of the iris is covered (excepting only in albinos) by a dense layer of cells containing black pigment, so that it is absolutely impenetrable by light. Its anterior surface is covered by pavement epithelium, continuous with that of Descemet's membrane. At birth, the anterior surface of the iris is invariably blue; and this color does not depend upon pigment, which is never present, but is what is called in optics an interference phenomenon, like the blue of the sky.[1]

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[1] [Wave interference has been invoked to account for the blue color of the iris in young children and blondes, and the experiments of Tyndall make it extremely probable that the blue color of the sky is the result of a physical condition dependent upon a certain degree of aggregation of molecules either of water or of some other substance; but it is by no means proved that the two phenomena have a common explanation.]

In a few eyes, the original interference blue is retained; but in the greater number pigment begins to be deposited in the anterior part of the stroma within a few weeks of birth. and the various familiar tints of gray, hazel, and brown are gradually produced. In cases in which the identity of children has been disputed, the color of the iris has more than once been appealed to; and it is important to know that all infants, even among the dark races, are born with blue eyes, and that surface pigmentation is always a subsequent occurrence, which may take place sooner or later, and in a greater or less degree. Albinos are again an exception, because in them the color of the blood, as shown by light reflected from the interior of the eye, is sufficient to overpower the blue which would otherwise be apparent. [In albinos the iris is of a bluish tint streaked with whitish lines, which are the thick-walled bloodvessels showing through the superficial layers of the iris tissue. The whole picture is further modified by the red of the strongly illuminated fundus shining irregularly through the more transparent parts of the iris. See Merkel, *op. cit.*, I, I, p. 29.] The margin of the pupil is somewhat bevelled at the expense of the anterior portion of the iris, so that in light irides the pupil is bordered by a fine dark ring of the posterior pigment layer, which is generally overlooked against the blackness of the pupillary space, but which may always be discovered if sought for, and which, when the pupil is rendered white by cataract, becomes a very conspicuous object. During a part of fœtal life the pupil is closed by a membrane, the *membrana*

FIG. 3.

Filament of Persistent Pupillary Membrane.

pupillaris, of which portions sometimes remain after birth. Fig. 3, shows a filament of persistent pupillary membrane, and was sketched from the eye of a boy twelve years of age. In health, and when seen through a healthy cornea, the iris presents a lustrous surface, an almost infinite variety of fibrillation and coloring, a circular outline and a free mobility of the pupil, which should expand under every passing shadow, and should contract with the smallest increase of illumination. In position, the iris, when seen in profile, should be vertical, forming the chord to the corneal arc; and should not be projected forwards towards the cornea. [All

recent authorities agree that the iris is not exactly vertical, but that it projects a little in its centre towards the cornea. It is supported in this position by the lens, with whose capsule the pupillary margin, except when the pupil is considerably dilated, is in contact.] Neither should it undergo tremulous movements in response to movements of the eyeball; such tremulous movements, when present, indicating that it has lost the support which it should naturally receive from the lens and vitreous body.

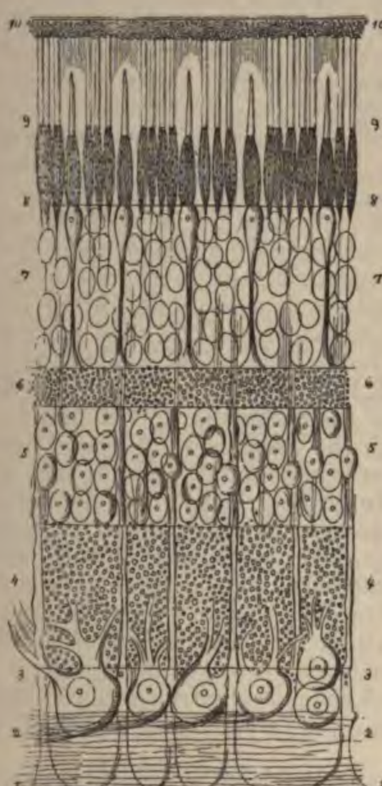
The inner or nervous tunic of the eye, called the retina (R, Fig. 1), is a highly complicated structure, which consists essentially of a percipient nervous apparatus for the reception of sensory impressions, and of a conducting apparatus by which these impressions are conveyed to the sensorium. The retina is in close contact with the inner surface of the choroid, and lines the whole of the posterior part of the eyeball. Its nervous elements terminate in front of the equator, and immediately behind the commencement of the ciliary processes, by a wavy or indented margin, called the *ora serrata* (Os, Figs. 1 and 2). It consists of ten layers, of which the most external, or that in immediate contact with the basal membrane lining the choroid, is a layer of pavement epithelium, consisting of very regular hexagonal cells, usually containing much pigment. This epithelial layer was formerly described as the most internal portion of the choroid; but Schultze and other recent observers have determined, mainly from the history of its development, that it should be regarded as belonging to the retina. As will be seen hereafter, it is of great importance to the ophthalmoscopic observer, because, in its normal state, and excepting in very light eyes, it is so filled with pigment as to form an opaque screen behind the nervous elements, and thus to cut off the structure of the choroid from view. It differs from the nervous elements in that it does not terminate at the ora serrata, but is continued over the whole internal surface of the choroid and of the ciliary body, and is finally merged in the posterior pigmentation of the iris. The layers of the retina have been differently named and divided by different histologists, but the following enumeration, which is now generally accepted, is that of Schultze, and proceeds from within outwards:

1. Internal limiting membrane.
2. Layer of nerve-fibres.
3. Layer of ganglion cells.
4. Internal molecular layer.
5. Internal granular layer.
6. External molecular or inter-granular layer.
7. External granular layer.
8. External limiting membrane
9. Layer of rods and cones.
10. Pigmented epithelium.

Fig. 4, represents a diagrammatic or imaginary magnified section of the retina (after Schultze), and the figures correspond

to those in the list given above. The only layers which demand attention from a surgical or practical point of view are three in number, namely, the epithelial, No. 10, which has been already described; the layer of rods and cones, No. 9; and the layer of nerve-fibres, No. 2; while those intermediate between 2 and 9 may be looked upon as subservient to the maintenance of the connection between the perceptive and the conducting function. The

FIG. 4.



Section of Retina—after Schultze—[and Schwalbe].

1, internal limiting membrane; 2, layer of nerve-fibres; 3, layer of ganglion cells; 4, internal molecular layer; 5, internal granular layer; 6, external molecular or inter-granular layer; 7, external granular layer; 8, external limiting membrane; 9, layer of rods and cones; 10, pigmented epithelium.

layers are all bound together by delicate radial fibres [fibres of Müller], which differ somewhat from those of ordinary connective tissue, but which appear to fulfil the same function, and which are certainly liable to connective-tissue diseases. They are also connected by fine filaments passing from the anterior to the posterior surface (as shown in Fig. 4), and probably forming the functional, as the radial fibres form the mechanical, bond of union

between them. At the posterior pole of the eyeball (fc, Fig. 1) there is a spot, about the size of the optic disk, in which the retina, elsewhere white or colorless, is tinged with yellow, and in the centre of this "macula lutea" there is a depression—the fovea centralis. At this point the layer of rods and cones is somewhat thicker than elsewhere, and layer No. 7 is fully developed; but the depression is formed at the expense of the anterior layers, which preserve their continuity, but are so thinned out as to be almost wanting, and are collectively bevelled off to form a pit with sloping sides. The fibrils of functional union follow this slope, and bend outwards until the proper thickness of the several layers is restored. The rods and cones, or ultimate nervous elements of the retina, sometimes collectively called "bacilli," are the organs of visual perception, and they are directed radially towards the centre of the eyeball, the apices of the cones resting on the pigmented epithelium. The cones are most abundant in the region of the macula lutea, where each one of them is surrounded by a single circle of rods; but in other parts of the retina the circle of rods around each cone is triple or quadruple. It is believed that the cones are the organs of the perception of color, which, with one apparent exception, is more acute in the macula lutea than elsewhere; but it can hardly be said that we possess any certain knowledge upon the subject. The conducting layer, or layer of nerve-fibres (No. 2), is formed essentially of the fibres of the optic nerve, which leave their sheaths at the lamina cribrosa of the sclera, pass through the scleral and choroidal openings, and bend round in bold curves (Fig. 1) to fall into the retinal surface. These fibres do not radiate symmetrically; but the nerve entrance being eccentric, the greater number pass to the temporal side, and are inclined either upwards or downwards, forming curves which meet on the horizontal meridian of the fundus, except at the macula lutea, where the fibres stop at its border instead of meeting. It is obvious that, as a mere matter of the quantity and the mechanical distribution of the fibres, the conducting layer must be thicker immediately around the nerve entrance than elsewhere, and that, excepting at the macula lutea, it must thin off gradually to the ora serrata.

The vessels of the retina, both arteries and veins, follow a course which generally resembles that of the nerve-fibres. The main divisions pass upwards and downwards from the nerve entrance, and curve around the macula lutea, while smaller branches turn to the nasal side. The vessels divide and ramify in an arborescent manner, which at once distinguishes them from those of the choroid; and they terminate in a capillary plexus, or in loops at the ora serrata. The larger branches are confined to the layer of nerve-fibres, but fine twigs are given off at right angles, and sink into the retinal tissue, to form a capillary network which does not penetrate deeper than the internal granular layer [external molecular layer. Leber, *Graefe und Saemisch; Handbuch*, II, I, p. 309.] Near the margin of the macula lutea the twigs terminate in loops,

and the capillary network itself stops short of the fovea centralis, which is extra-vascular. The veins mostly accompany the arteries, or lie near to them, and the circulation of the retina is almost independent. It does not anastomose with that of the choroid at the ora serrata, but receives some very minute twigs from the ciliary vessels at the entrance of the optic nerve into the eye.

The tunics hitherto described inclose an approximately spherical cavity, which is divided into two portions by the crystalline lens and its suspensory ligament. The smaller and anterior portion is subdivided by the iris into the anterior and the posterior chambers, and contains the aqueous humor; the larger and posterior portion contains the vitreous body. The cornea, aqueous humor, lens, and vitreous are collectively described as the transparent or refracting media. Through them light passes to reach the retina, and, by their optical properties, it is so arranged as to form defined images upon the layer of rods and cones.

The crystalline lens (L, Fig. 1) is a transparent bi-convex, highly refracting substance, more convex posteriorly than anteriorly, usually about nine millimetres in diameter and from three to four in thickness, and inclosed within a transparent and homogeneous capsule; it is suspended vertically from the ciliary processes, and is in contact, when the pupil is contracted, with the posterior surface of the iris. [The surface of contact between the iris and the capsule of the lens is confined to a rather narrow ring immediately surrounding the pupillary margin] It consists of concentric laminæ; and these laminæ are formed of three or more portions, so that after maceration, the lens may either be peeled into layers like an onion, or broken into three or more sectors along lines radiating from its centre to its circumference. The laminæ are composed of fibrillæ, which are flattened hexagons in section, and are finely serrated at their borders in such a manner that the serrations interlock and form a highly elastic and resisting structure. The external laminæ are softer than the internal, a difference which gives rise to a division of the lens into nucleus and cortex, but to these divisions no boundary line can be assigned. The lens becomes harder, drier, and more resistant as life advances; and, having been originally colorless, it assumes in old age a yellowish or amber tint. The capsule which incloses it, and which is described as consisting of an anterior and a posterior capsule, is a structureless membrane like that of Descemet. The suspensory ligament, or zonule of Zinn (ZZ, Fig. 1), is a fine transparent circle of fibrous tissue,[1] which is continuous with the investing membrane of the vitreous body, and with the external limiting membrane of the retina[2] passes over and is adherent to the ciliary processes, and extends from their anterior extremities to be inserted into the anterior and

[1] [The suspensory ligament of the lens shows a structure made up of fibres, but of a very different character from ordinary "fibrous tissue."]

[2] [This statement is taken, though not quite correctly, from Merkel; the point is discussed at length by Arnold: *Graefe und Saemisch; Handbuch*, I, I, p. 805–6.]

posterior capsule of the lens, a little on either side of its equator. The suspensory ligament thus intervenes between the circle of the ciliary body and the margin of the lens, and forms the medium through which the lens is acted upon by the ciliary muscle. How this action is effected is not quite clear, but it is surmised that the contraction of the muscle relaxes the zonule, and permits the lens to become more convex by its own elasticity. It is at least certain that the convexity of the lens is increased by [simultaneously with] the action of the muscle, and that the maintenance of the necessary effort is often fatiguing or even impossible.

The cavity of the aqueous humor is bounded anteriorly by the posterior surface of the cornea, posteriorly by the anterior surfaces of the ciliary processes, by the zonule of Zinn, and by the anterior capsule of the lens. In this cavity the iris stands as a vertical screen with a central perforation which is occupied by the anterior pole of the lens. When the pupil is small, its margin rests upon the lens, and the aqueous space behind the iris, the posterior chamber, PC, Fig. 1, is cut off from AC, the aqueous space in front of the iris, or the anterior chamber. The aqueous humor, by which both cavities are filled, is as nearly as possible pure water, containing no albumen, and, in health, not more than about one part in a thousand of the saline constituents of the blood. The quantity of the aqueous humor is such as to fill its cavity, and it is rapidly re-secreted when evacuated by puncture.

Behind the lens, the whole of the posterior cavity of the eyeball is accurately filled by the vitreous body (VB, Fig. 1), which presents to the naked eye the appearance of a transparent mass of colorless jelly. By injection, it is possible to demonstrate the existence of a channel in this substance (the hyaloid canal) extending from the optic disk to the posterior pole of the lens. This channel, during fœtal life, gives passage to the hyaloid or nutrient artery of the lens, with its companion veins. These vessels are part of the retinal system of circulation, and in a few very rare cases they remain pervious throughout life. Generally speaking, they disappear prior to birth, and I have seen one case in which their remains became expanded into a delicate pellucid cyst, which was attached to the optic disk, and presented a very deceptive resemblance to a cysticercus. The vitreous body is said to be contained within a hyaloid membrane, which is distinguishable with difficulty, if at all, from the internal limiting membrane of the retina. The gelatinous substance consists chiefly of water, containing some mucin, and is supported by a web of fine tissue, the fibres of which have as nearly as possible the same index of refraction as that of the fluid. The density of the vitreous is greater externally than towards the centre, and it may be made to exhibit traces of a laminated structure. [The vitreous body is of a firmer consistence externally than in its central portions: when treated by reagents it takes on a variety of appearances, some of which are certainly wholly artificial, while others seem quite clearly to point to a pre-existing structure.] Its consistence and composition

differ much in different animals, and in most of the mammals it is much firmer than in man, so that experiments and observations upon animals cannot be relied upon for the establishment of conclusions applicable to the human subject. Clinical observation shows that is liable to undergo fluid degeneration, and also, although it contains no vessels, that processes which can only be called inflammatory may take place within its structure. It is liable, especially in syphilis, to be rendered turbid by cell proliferation, and it occasionally becomes partly or entirely converted into pus.

Of the conjunctiva, or mucous membrane of the eye and eyelids, which is indicated at Ca, Fig. 1, it is here only necessary to observe that its ocular portion is separated from the sclera by a lax connective tissue, which becomes more scanty in the vicinity of the cornea, and disappears altogether at its margin, where the conjunctiva also terminates by being firmly attached to the sclera, except that its epithelium alone is continuous with that of the corneal surface. The conjunctiva is very vascular, and its vessels, which are not usually conspicuous, become much and quickly distended by even a small amount of irritation. On the nasal side, near the inner canthus, the conjunctiva presents a fold, the plica semilunaris, which has its concavity turned towards the cornea, and is more conspicuous in some persons than in others. This fold appears to be only a rudiment of the nictitating membrane, or third eyelid, which is possessed by many birds and animals, and it has no special function in man. Still nearer to the inner angle of the lids is the "caruncle," a small rounded eminence of connective tissue, covered by conjunctiva, and sometimes studded by a few fine hairs. [The caruncle is a bit of somewhat modified skin in which are implanted a number of very fine hairs with relatively very large hair follicles and sebaceous glandules; besides these it contains several modified sweat-glands of large size, together with muscular fibres of both the smooth and striped varieties. Waldeyer in *Graefe und Saemisch; Handbuch*, I, I, p. 245.]

The optic nerve (ON, Fig. 1), upon which the eye is dependent for the conveyance of visual impressions to the sensorium, takes its origin by two roots from the corpora geniculata, and these roots, after their union, pass forward on either side, under the name of the optic tracts, to form the chiasma, or optic commissure, in front of which they are called the optic nerves. In the chiasma the nerve-fibres intercross in a complicated manner, and finally proceed, those from the right tract to the left eye, and *vice versâ*. It was recently believed that the decussation was only partial, and that the external fibres of each tract went to the external portion of the retina on the same side; but this view is not supported by the latest investigations, and the pathological phenomena upon which it partly rested seem to admit of another explanation. [The latest investigation seems to show that, after all, the decussation of the optic nerve-fibres in the chiasma is not total, but partial. Gudden in *Archiv für Ophthalmologie*, XX, II, and XXI, III.] The nerve carries with it from the brain an inner sheath or neurilemma de-

rived from the pia mater, which sends many fine septa into the trunk, and thus divides the fibres into bundles. These septa convey bloodvessels from the neurilemma, so that the capillary circulation of the nerve is derived from, and is continuous with, that of the pia mater. On entering the orbit, the nerve receives a second or external sheath from the dura mater, which there splits into two layers, one of which forms the sheath aforesaid, while the other lines the orbit as periosteum. Between the two sheaths of the nerve there is an interval, occupied only by lax connective tissue, and directly continuous with the arachnoid cavity. This interval, which is often called the intervaginal space, becomes less evident as the nerve approaches the eye, and it terminates as a cul-de-sac at the level of the lamina cribrosa, as shown at IS, in Fig. 1. [A third sheath, very delicate and in close relation to the outer or dural sheath, is now recognized; it is described as continuous with the cerebral arachnoid membrane. The *intervaginal space*, so-called, is continuous with the subarachnoidal cavity of the cranium, but it sometimes happens, in cases of serous effusion into the sheath of the nerve, that the subdural, or true arachnoidal space becomes greatly distended. The two spaces appear, moreover, to communicate freely with each other through openings in the arachnoidal sheath, in the neighborhood of the eyeball. Schwalbe, *op. cit.*, I, I, page 329.] The nerve pursues a somewhat curved course along the axis of the orbit, and enters the eye through the scleral and choroidal openings, about four millimetres to the nasal side of the posterior pole, and something below the horizontal meridian. The outer sheath becomes blended with the sclera, and the inner sheath terminates at the lamina cribrosa, or at most sends a few fibres into the choroid. The central artery of the retina pierces the sheaths of the nerve about half an inch posterior to the eye, and, with its companion vein or veins, occupies thenceforward an almost axial position within the trunk. At the lamina cribrosa the individual nerve-fibres lose their sheaths, and the septa of connective tissue become extremely fine and thin; so that the total diameter of the nerve is diminished by about one-half. [At the lamina cribrosa the connective-tissue septa of the nerve are lost in the septa of the lamina; these last are, however, quite firm and thick, and the diminished diameter of the nerve is due to the nerve-fibres having lost their sheaths.] The uncovered nerve-fibres bend round, as already described, to constitute the fibre layer of the retina; and the septa continue to form the delicate connective tissue of that membrane.

The eyeball, thus constituted, is suspended in the orbital cavity, a little on the temporal side of its axis, by means of six muscles, the four recti—superior, inferior, internal, and external—and the superior and inferior oblique. The four recti and the superior oblique take their origins at the apex of the orbit. The recti diverge to receive the globe, and then, coming into contact with it a little behind the equator, embrace it closely until they are inserted into the sclerotic by flat tendons at a short distance from the cornea.

The insertion of the internal rectus is nearer to the corneal margin than that of the external, and the insertions of the superior and inferior are still more remote The breadth of the tendons varies with the general muscular development of the individual; but the internal is usually the strongest and largest of the four straight muscles. The superior oblique ascends to the inner and superior angle of the orbit, where it passes through its well-known pulley, and its tendon then descends at an angle, and passes under the superior rectus, to be inserted into the sclerotic on the posterior hemisphere, just by the upper margin of the external rectus The inferior oblique takes its origin from the lower angle of the inner wall of the orbit, near the opening of the nasal duct, and passes somewhat backwards and outwards, below the inferior rectus, to be inserted in a line opposite that of the superior oblique. The expression used above, that the muscles come into contact with the globe, is not literally correct, for they are separated from it by a fibrous capsule, the capsule of Tenon, which their tendons perforate. This capsule is attached posteriorly to the sclerotic, in a circle somewhat in front of the nerve entrance, and anteriorly is lost in the conjunctiva, near the corneal margin. [Tenon's capsule is attached posteriorly to the sclerotic, by very loose areolar tissue only. That portion of the capsule which is behind the equator of the eyeball may be described as forming an incomplete hemispherical cavity, whose deepest part presents a large and somewhat ill-defined opening, about a centimetre in diameter, which gives passage to the optic nerve. See Merkel, *op. cit.*, I, I, p 57.] Where the tendons perforate it, they also receive sheaths from it, and carry them to the sclerotic. The space between the eyeball and the capsule contains lax connective tissue, which admits of easy inflation by a blowpipe, and which facilitates the free rotation of the globe about its centre, in response to every contraction of its guiding muscles. Together with the structures already described, and with the nerves and bloodvessels of the eye and its appendages, the orbit contains the levator palpebræ superioris, which passes over the superior rectus, to be inserted into the margin of the tarsal cartilage of the upper lid; and the rest of the cavity is mainly occupied by the lacrymal gland, and by connective and adipose tissues, which facilitate the ocular movements.

Besides the optic nerve, the eye and its appendages receive sensory branches from the first division of the fifth, and motor branches from the third, fourth, and sixth nerves [the *orbicularis palpebrarum* muscle is supplied by the *portio dura* of the seventh nerve], and from the sympathetic. The three chief branches of the first division of the fifth, the lacrymal, the frontal, and the nasal, all send cutaneous twigs to the eyelids and to the conjunctiva, and it is probable that some of these reach the cornea; but the manifest contributions of the fifth to the eyeball are derived from the nasal branch, which gives off the superior or long root of the ciliary, ophthalmic, or lenticular ganglion, and also the two or three "long" ciliary nerves, the course of which will be presently men-

tioned. The third nerve supplies the sphincter of the iris, the ciliary muscle, and all the muscles of the eyeball, excepting the external rectus and the superior oblique. It divides within the orbit into two main branches, of which the superior and smaller passes inwards across the optic nerve to the superior rectus and the levator palpebræ, while the inferior and larger divides into three parts. One of these passes beneath the optic nerve to the internal rectus, another to the inferior rectus, and the third passes forwards between the external and inferior recti to the inferior oblique. From this nerve a short thick branch is given off to the ciliary ganglion, forming its lower root, and two filaments are given to the inferior rectus. The fourth nerve proceeds to the superior oblique, and the sixth to the external rectus. The ciliary ganglion, which derives its sympathetic root from the cavernous plexus, and is reinforced from the third and fifth nerves in the manner described, gives off ten or twelve delicate filaments, the short ciliary nerves, which, accompanied by the long ciliary branches from the nasal, lie above and below the optic nerve, and perforate the sclerotic in a small circle around it. The ciliary nerves, long and short together, pass forwards between the choroid and the sclerotic, grooving the internal surface of the latter, and ramifying and anastomosing as they proceed, until they reach the ciliary region, where they form an intricate plexus from which the iris, ciliary muscle, cornea, and bloodvessels are supplied. The ultimate distribution of the fibrils from the different sources has been chiefly determined by analogy and by the observation of disease. Paralysis of the muscles which are known to be supplied by the third is almost invariably attended by paralysis of the sphincter pupillæ and of the muscle of accommodation, whence it is inferred that these derive their motor power from the same source. [Division of the third cranial nerve in animals is followed by paralysis of the sphincter pupillæ: mydriatics both dilate the pupil and paralyze the accommodation, and the myosis produced by calabar bean is always associated with accommodative spasm.] Division or injury of the cervical sympathetic produces contraction of the pupil and passive congestion of the eye; whence it is inferred that the sympathetic supplies the dilatator pupillæ and the vaso-motor branches. About the fifth, as a nerve of sensation, there can be no doubt, and there is much reason to believe that it also ministers to distinctly trophic functions. It is at least certain that the nutrition of the eyeball is liable to suffer greatly when the fifth nerve is irritated or diseased.

The blood-supply of the eye and its appendages is derived from the ophthalmic branch of the internal carotid artery, and is chiefly returned through the ophthalmic vein into the cavernous sinus. The arteries of the globe are divided into the short, long, and anterior ciliary. The short and long ciliary pierce the sclerotic in the neighborhood of the ciliary nerves. The short arteries, of which there are twelve or fifteen, are mainly distributed in the choroid; the long, two in number, pass forwards under the sclerotic

with little ramification until they reach the ciliary body, when they break up into twigs, which chiefly proceed to the iris to form its greater and lesser arterial circles, and which also supply a zone of fine vessels to the sclerotic, immediately around the margin of the cornea. The anterior ciliary arteries are derived from muscular branches which pierce the anterior part of the sclerotic and proceed to the iris. The eyeball, as well as the conjunctiva, probably receives twigs from some of the palpebral branches of the external carotid, and some of its veins discharge themselves into the facial vein. Others, which perforate the sclerotic not far from the corneal margin, course backwards under the conjunctiva, and, together with the trunks of the venæ vorticosæ, proceed to the ophthalmic vein.

The anatomy of the eyelids requires only a cursory mention. Each one is formed by a thin plate of cartilage,[1] convex externally, concave internally, and moulded to fit accurately to the contour of the globe. These cartilages are lined by the reflected conjunctiva, which is very thin and smooth and closely adherent to them, and they are covered by the orbicularis muscle and by a thin common integument. At their free borders the lids are rather broad, and are so bevelled that only the anterior margins of these borders come into contact when the eyes are closed.[2] From the anterior margin of each lid a row of strong slightly curved hairs, the cilia, or eyelashes, project forwards, and within the cilia are the orifices of the Meibomian glands, which keep the edges of the lids lubricated by a greasy secretion which forms a barrier to the overflow of tears. The conjunctiva lining the cartilages contains numerous papillæ analogous to those of the dermis; and, where it is reflected from the cartilages to the globe, it forms a loose fold (the retro-tarsal fold), and is thickly studded with minute lymph-glands. Near the inner canthus, or angle of the palpebral aperture, there are two small openings, the puncta lacrymalia, situated one on the margin of each lid, and leading to the tear-passages. Between the puncta and nearer to the middle line, filling the angle, is the little fleshy substance called the caruncle, which has been already described. The length, thickness, and abundance of the cilia differ much in different persons; and the integument of the lids is apt to lose its tone, and to fall into lax folds and wrinkles, as one of the changes incidental to declining years.

If we proceed now to the physiology of the eye, we find that its essential function almost precisely resembles the action of a photographic camera. As this, when properly adjusted, produces upon its glass screen defined inverted images of the objects to which its lens is directed, so the refracting media of the eye should produce defined inverted images upon the layer of rods and cones of the

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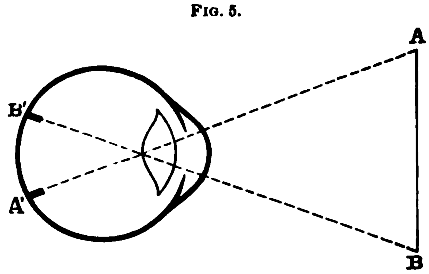
[1] [The so-called tarsal cartilage is not cartilage at all, but a very firm and dense fibrous or connective tissue.]

[2] [The margins of the closed lids are in accurate contact throughout their whole breadth. See Merkel, *op. cit.*, I, 1, p. 85.]

retina; and the whole of its mechanism may be regarded as being subservient to this end, or to the carrying on to the sensorium of the impressions which are thus produced. If either the conducting function of the optic nerve, or the perceptive function of the retina, should be abolished, there will be no vision at all; but, whilst the nerve and the retina are healthy, the quality of vision depends entirely upon the transparency of the refracting media, and upon the perfection of the optical images which they form. If the media themselves, though still translucent, have become turbid, vision may be reduced to a simple perception of light; and, even when they are transparent, if the image cast upon the retina should, from any optical fault, be blurred or ill defined, the impression conveyed to the consciousness will be of a like imperfect character. The majority of persons are rendered conscious of the possession of eyes only by the continual reception of clear images from the objects at which they look, whether these are near or remote. The minority, and that not an inconsiderable one, either enjoy clear vision only under certain limitations with regard to distance, or use their eyes by an effort which is always perceptible, soon irksome, and at last painful or fatiguing. Some people can see clearly only a few inches before them; others only for a range extending from arm's length to the horizon; others, who may be wholly free from disease, have not perfect vision at any distance, and yet are often unconscious of the defect under which they labor. In the meanwhile, in the estimation of the public, one eye is as good as another; and although it is manifest that the differences above-mentioned must greatly influence the fitness of individuals for this or that vocation in life, yet we scarcely ever hear of these differences being taken into account in the training of children, or in the choice of professions for young men. It is quite common for a child with defective sight to be repeatedly punished, both at school and at home, for errors which he is unable to avoid; and there are numbers of people in the world who, by the continued operation of similar ignorance or thoughtlessness in their more mature years, are tied to occupations which are to them continual sources of discomfort, and sometimes sources of danger. The merely structural imperfections of healthy eyes are matters which require, both from the medical profession and from the public, a greater degree of attention than they have hitherto generally received. The peculiarities of the organs as optical instruments have tended to place them outside the boundaries of ordinary physiological research; and hence, during many years, optical philosophers unacquainted with physiology were suffered to build up a fanciful structure, composed of hypotheses at once ingenious and erroneous, with regard to the nature and uses of the several parts of the eye, and with regard to the degree of physical perfection which it usually attains. Before attempting to dissipate some of the unfounded beliefs which have been thus produced, there are certain general questions which require a brief consideration.

The inversion of the retinal image, which has been mentioned as a feature common to the eye and the camera, is a necessary result of the intercrossing of pencils of light which have passed through a small aperture, or have been refracted by a convex lens, and the rationale of the matter is too fully set forth in books on natural philosophy to require description here. But it is only comparatively recent knowledge of the anatomy of the retina which enables us to understand how it is that the inverted image produces erect vision; a question which was long warmly debated by the learned. It is now manifest that it is not the retina as a whole organ which perceives, but that each individual bacillus in the retina perceives its own share of the picture formed upon the general surface. And, as the bacilli stand radially upon the inner aspect of the posterior hemisphere of the eyeball, they are so directed that each will see its own part of the object in its proper

FIG. 5.



place. In Fig. 5, for example, the line A B represents an object, and A′ B′ its inverted image upon the retina But the individual bacillus at A′ looks up towards the point A, and sees the direction from which the light comes: while in like manner the individual bacillus at B′ looks down towards the lower part of the object. As regards the retina as a whole, the inversion produces its natural effects, whenever there is any localized loss of vision. A detachment of the upper half of the retina may leave the stars visible, while it takes away the power of seeing the ground; and a detachment of the lower half produces a darkness above which patients often compare to having the peak of a cap pulled down over the eye. Hæmorrhages, and other local changes, must also be looked for in a direction opposite to that of the gap which they produce in the visual field.

The axis of the globe has been already defined to be an imaginary line drawn from the fovea centralis to the geometrical centre of the cornea. The axis of vision, on the other hand, is an imaginary line drawn from the fovea centralis through the object looked at, and it is seldom coincident with the axis of the globe, but forms with it a small angle. Along the axis of vision, we have the range of vision, which lies between the near point and the far point—terms which sufficiently express their own meaning, but which

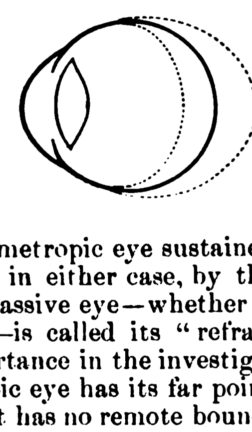
refer, as will be seen hereafter, to different localities in space in different individuals.

The occurrence of single vision with the two eyes is a matter which has given rise to much speculation, and of which we know little more than that it takes place only under certain conditions. We can combine the two images, so as to receive from them a single impression upon the consciousness, only when they are symmetrically disposed upon the two retinæ.

The most common manner in which the eyes depart from what may be considered a normal standard is by some disproportion between the length of the axis of the globe and the optical power of the refracting media. Every convex lens—and the refracting media collectively may be so considered—has a special distance at which alone it produces a clear image of a given object. The distance of the clear image from the lens is known as the focal length of the latter, and it increases as the object is brought nearer; so that, in the camera, we have a screw [or rack] adjustment by which to vary the position of the lens, according as we want an image of a near or a remote point. In the eye, the distance between the lens and the retina cannot be varied; but the same result is produced by increasing the strength of the lens by the action of the ciliary muscle. When this muscle is at rest, the lens is at its weakest, that is to say, it has its greatest focal length; and, as the muscle contracts, the lens becomes more convex, stronger, or of smaller focal length. This change is called "accommodation," since by its means the eyes are "accommodated" to vision at different distances. Perhaps the best example of the need of accommodation is that given by Donders—namely, that if we place a page of print as far away from the eyes as we can read it comfortably, and look at it through a piece of net held somewhat nearer to us, we shall find that when we accommodate for the distance of the type, so as to read, we cannot distinctly see the fibres of the net, and only recognize some indefinite intervening film. On the other hand, when we accommodate for the shorter distance, and see the fibres of the net sharply and distinctly, we cannot at the same time read the type, although our gaze is still directed towards it. The normal or ideal eye is one in which the axis of the eyeball is of the same length as the focal distance of the refracting media for remote objects; so that, in looking at the horizon, the eye sees clearly, although it is quite passive; and accommodation is only brought into play for objects that are nearer at hand. Such an eye is said to be "emmetropic," and one that does not fulfil the assigned conditions is said to be "ametropic." It is obvious that there may be two contrasted forms of ametropia; one, in which the axis of the eyeball is shorter than the focal length of its media; another, in which the axis is longer than the focal length. The first form is called "hypermetropia;" and in it, as the focal length is greater than the axial length, there is no clear vision until the former is diminished by accommodation. Accommodation is therefore called into constant exercise, and the ciliary muscle is

never passive. It is exerted, more or less, according to the degree of the hypermetropia, in looking at distant objects, and still more when the gaze is directed to near ones. The eyes soon become tired by the unremitting effort which is thus demanded from them; and the mere continuance of seeing is in itself irksome. The flatness of a hypermetropic eye is generally [in the higher grades of hypermetropia] very manifest when it is turned towards the nose and looked at from the temporal side; and the malformation, for reasons to be discussed hereafter, produces liability to convergent squint. In the other form of ametropia the axis of the eyeball is longer than the focal length of the media, the globe being unduly elongated from front to back. There is then no distinct vision except for near objects; and the eye is said to be short-sighted or near-sighted. For this condition the most correct name would be hypometropia; but the trivial designation "myopia," which was applied to the associated defect of vision long before its nature was understood, is too firmly established to be disturbed for the sake of symmetrical nomenclature We have thus three types of eye, all of frequent occurrence. The normal, or emmetropic type, is shown by the dark line in the annexed diagram, Fig. 6; while the hypermetropic type departs from it in the direction of the internal dotted line, and the myopic type in the direction of the external dotted line. For the myopic distant vision is impossible, and for the hypermetropic eye sustained near vision is generally impossible, except, in either case, by the aid of optical appliances The state of a passive eye—whether it is emmetropic, hypermetropic, or myopic—is called its "refraction," and is often an element of great importance in the investigation of diseased conditions. The emmetropic eye has its far point at infinite distance, so that its range of sight has no remote boundary, while its near point is at a distance determined by its power of accommodation. The myopic eye has its far point at some finite distance—such as one foot or three feet—beyond which it cannot see clearly, and its near point within this distance; while the hypermetropic eye, in its passive state, has no actual far point or near point, and no clear vision at any distance, except by the exercise of accommodation. [The myopic eye has its far point at some finite distance and its near point nearer than in the emmetropic eye; the hypermetropic eye has "no clear vision at any distance except by the exercise of the accommodation," and in extreme cases not even then, for the reason that the refractive defect may be so great that the total accommodative power is insufficient to adjust the eye even for distant, much less for near vision]

FIG. 6.



The function of accommodation, by which the refraction is modified, depends upon the elasticity or plasticity of the crystalline lens, and upon the degree in which its shape can be altered by

varying states of the ciliary muscle. The lens is believed to possess its maximum of plasticity at about eleven[1] years of age, and from that time, as life advances, it becomes gradually harder, with corresponding loss of accommodation. As accommodation diminishes, the near point recedes farther and farther from the eye, and the nearest portion of the range of vision is curtailed in a corresponding manner. This change is a perfectly natural one, which occurs in all eyes; and the resulting imperfection of function, when it attains a conspicuous degree, is denominated "presbyopia," or aged sight.

Apart from these variations, a chief difference between the eye and a camera, or any artificial optical instrument, depends upon the greater extent of field which the eye embraces. This field may be said to extend over 160 degrees from side to side, and over 120 degrees from above downwards; but whereas, in the artificial instrument, we demand clear definition to the margin of the field, wherever this may be, in the eye we obtain clear definition only in the centre, over a space which would contain, at the distance of a yard from the cornea, about four letters of the type in which this page is printed. [The diameter of the *fovea centralis* corresponds, in the field of vision, to an angular magnitude which can be covered by the nail of one's forefinger when the hand is stretched out as far as possible.—Helmholtz, *Popular Lectures on Scientific Subjects: "The Eye as an Optical Instrument."*] Within such a space, a normal eye should be able to distinguish two points separated by about a sixteenth part of the space itself, or by one minute of angular measurement; but, beyond its boundaries, vision becomes progressively more and more indistinct up to the limits of the field. The image formed within the eye has been well compared to a drawing, of which the centre is exquisitely finished, while the marginal parts are merely sketched in outline. Of these we see, indeed, enough to call our attention to any noteworthy objects or phenomena; towards which, as soon as we are thus warned of their presence or occurrence, the direct gaze will be immediately turned, allowing the previous object of regard to pass out of sight, or to lapse into marginal indistinctness. The mobility of the eye almost neutralizes, so to speak, the narrowness of the field of exact vision; insomuch that the fact of this narrowness is unknown to the majority of persons, and becomes a matter of surprise when shown by observation or experiment. In technical language, the acute vision with which we see objects upon which the attention is fixed is called *direct vision;* and the imperfect vision, which renders us conscious of the main outlines of lateral objects, is distinguished as *indirect.* The former is the function of the fovea centralis and macula lutea only; the latter, of the whole of the lateral portions of the retina, in which the percipient elements are overlaid by the granular, the ganglionic, and the fibre layers.

[1] [We are not aware of any investigations fixing thus definitely the age at which the plasticity of the lens is at its maximum.]

The eye differs, moreover, from all the compound instruments of the optician, in the absence of any provision for the correction of what are called in optics the "aberrations" produced by refracting media. These aberrations are of two principal kinds, the "chromatic" and the "spherical."

Chromatic aberration is a consequence of the compound character of solar rays, which are made up of different kinds of light, all refracted in different degrees by any single substance, and therefore incapable of being united by it in any single focus. Because we are not sensible of color fringes round the objects of our regard, it was long supposed that the eyes were achromatic, and that their achromatism was produced, as in compound lenses made by art, by differences in the powers of refraction and dispersion of the successive media, the cornea, the aqueous humor, the crystalline lens, and the vitreous body. But recent research has shown that the eyes are so far from being achromatic that, when accommodated for infinity in red light, they are only accommodated for a distance of about two feet in violet light; and this may be made manifest by looking at any distant flame which is covered by a cobalt-blue glass. Such a glass transmits the red and the violet, but absorbs the yellow and the green rays of the spectrum; and persons with normal vision see through it a defined red flame, surrounded by a wide halo of bluish violet.

Spherical aberration, in glass lenses, produces distortion of the image at the margin of the field[1] It depends upon the fact that divergent rays strike the surface of the lens at different angles near the centre and at the margin, and are more sharply refracted at the latter; so that the focus of the marginal portion is nearer the lens than that of the central portion. If we look at any surface through a moderately strong magnifier, and gradually increase the distance between the two, we shall soon reach a point at which the marginal image is blurred, while that of the central portion is still distinct and clear. Opticians remedy this defect by the use of diaphragms, or "stops," opaque plates with central openings, so that the marginal part of the lens is covered.' It was long believed that the iris, in the human eye, fulfilled an analogous function; but exact investigation has shown that it does so, if at all, in a very imperfect manner.[2] In truth, the curvatures of the

[1] [Spherical aberration is a necessary result of the employment of spherical surfaces in grinding lenses, perfect spherical surfaces not making a perfect lens. It increases with the increase in the diameter (or aperture) of the lens, but at a more rapid rate, and its effect is the formation of an image which is indistinct in all its parts. The indistinctness or blurring of the marginal portions of the image, as in the experiment described in the text, is dependent on quite another cause, viz., the fact that the marginal portions of the object are further than its central portions from the centre of the lens.]

[2] [Although spherical aberration, in a strict sense, cannot exist in the eye, for the reason that its refracting surfaces are not true spherical curves, its defects are still of a kind to be greatly diminished in their effect upon the acuteness of vision by the action of a "stop" or diaphragm, and this function the iris exactly and efficiently performs, by excluding the marginal portions, both of the lens and of the cornea, from participation in the formation of the retinal image in direct vision.]

surfaces of the eye are exceedingly irregular, generally not spherical at all, but ellipsoidal, and different in different directions; and these ellipsoidal surfaces are not always concentric, the centre of the crystalline lens being often out of line with that of the cornea. The result is that there are few people who can see horizontal and vertical lines, at the same time and at the same distance from the eye, with the same degree of clearness; and the optical picture formed by the refracting media upon the retina is often distorted in a degree compared to which any defects due to spherical aberration would be inappreciable. Besides this distortion there is another, traceable to the fibrillated structure of the crystalline lens, which causes us, when we regard any distant point of light, such as a star, to see it surrounded by an appearance of rays. These rays have, of course, no objective existence, and they differ in their arrangement in the eyes of each spectator.

The media of the eye, in reality, are far from being either homogeneous or perfectly transparent. If we look through a very small opening upon an illuminated surface (the best method is to make a pinhole in a thin sheet of metal, and to place it over the eyepiece of a microscope, with moderate mirror illumination of the objective), we shall see the field of view occupied by many stationary granules or spherical objects, by some stationary fibres, and by many floating fibres, which resemble beaded filaments. All these are shadows cast upon the retina, and then projected outwards as visible objects; the stationary shadows being cast by imperfectly transparent parts of the crystalline lens; the floating shadows by imperfectly transparent fibrillæ in the vitreous; and the imperfect transparency being due to the presence of nuclei, or even to some difference between the index of refraction of a cell or fibre, and that of its surrounding parts. Again, the media present phenomena of fluorescence and interference which are very marked if we seek them properly. If we throw a fine pencil of light through the fully dilated pupil, we can distinctly follow its track into the depths of the eye by the reflection of its blue waves from the organic particles against which they break; and, if we light up either the cornea or the crystalline lens with blue rays only, we shall see a reflex, like that of a solution of quinine, from these apparently colorless structures.

The retinal surface which receives the image has its full share of imperfections. Over the entrance of the optic nerve, where the layer of rods and cones is wanting, it is absolutely blind; and this blind spot measures not less than six degrees in the horizontal, by eight in the vertical direction. If we draw on a piece of paper a small dot or cross as an object, and three or four inches to the right of it a black circle half an inch in diameter, and if we look steadily at the dot with the right eye only, while we move the paper to and fro, we shall soon find a distance at which the black circle vanishes. The larger retinal vessels also form "blind lines" radiating from the spot; and a point of light may be made to disappear as it passes across or along them. Under certain conditions,

moreover, they cast shadows upon the percipient layer, and thus interfere with the perfection of the retinal image.

Lastly, the centre of vision, the yellow spot itself, by reason of its own tint, occasions deceptive color sensations, and masks or overpowers feeble luminous impressions. It is well known that some of the smaller stars are seen more readily when we look a little aside from them than when we look at them directly; and this is due to the coloration of the yellow spot, by which the star is as much disguised as if it were looked at through a piece of yellow glass. Professor Clerk Maxwell, in a lecture at the Royal Institution, pointed out that, in consequence of differences in the tint of the yellow spot, a color which one person, on comparing it with white, would call pinkish, would be said to be greenish by another. He also displayed a method by which the presence of the yellow coloring matter in the retina may be rendered manifest; a method for which he was indebted to Professor Stokes. It consists in looking at a white object through a solution of chloride of chromium, or at a white screen on which light which has passed through this solution is thrown. The solution transmits a mixture of red light with the rays near the line F—that is, in the middle of the blue—[between the green and the blue] of the prismatic spectrum, which are strongly absorbed by the yellow spot. When this mixture falls on the general surface of the retina, it appears of a neutral [sea-green] tint; but when it falls on the yellow spot, only the red light reaches the percipient nervous elements, and a red patch is seen floating like a rosy cloud over the illuminated field.

All the sensations produced by color, beyond the region of the yellow spot, are different in different parts of the retina, and are less vivid, certain, and distinct in the marginal parts than near the centre. The margin, for example, is nearly insensible to red; so that the outline of a red object can be seen when it is held far to the right or left, long after its color has ceased to be distinguishable. Again, in a feeble light, red objects become comparatively invisible [or rather indistinguishable]; as all know who have tried to find red fruit in the twilight of a summer evening.

We arrive, in this way, at a somewhat formidable total of imperfections in the eye, when it is regarded as an optical instrument; and it becomes interesting to inquire why they interfere so little with its efficiency as an organ of vision. The answer must be afforded, first, by the imperfect attention which is naturally paid to any indirect visual impressions, that is, to any appearances which can only be seen if they are sought for in the outer parts of the field, while the direct gaze is turned away from them; secondly, by the faculty of accommodation; thirdly, by the degree in which our conclusions about what we see are the results of an experience in which the eyes are aided by the reports of other senses; and, lastly, by the influence of habit.

The prevailing disregard of the phenomena of indirect vision can hardly be better illustrated than by the fact that it was reserved for Mariotte, in the reign of Charles II, to discover the ex-

istence of so considerable a lacuna as the blind spot. Before his time, men had used their eyes for thousands of years, and yet they had so constantly neglected the latter portions of the field that they never became conscious of these great defects in them. The two blind spots were one on either side of the object looked at, and were always, therefore, both out of sight and out of mind. It was only when Mariotte, wishing to test the share of the choroid in vision, designedly brought the image of an object upon a part in which the choroid is wanting, that he found out the insensibility of the optic nerve to light. Few people even now are aware that they cannot distinguish red with any marginal part of the retina. When they want to distinguish red, they instinctively look *at* it; and then it is seen by a part which is no longer marginal. Many of the phenomena of aberration are localized in the same manner; and they are thus so utterly disregarded that their very existence remains unknown.

The function of accommodation has been already described as that by which the yellow spot receives sharply defined images of objects, at whatever distance they may be situated; by which, in the language of optics, the eye is adjusted to see clearly either from afar or at hand. The rays of light from distant objects are approximately parallel; and an emmetropic eye, when in repose, unites them into a clear picture upon the retina. The rays from near objects are no longer parallel, but divergent; and the same adjustment would no longer unite them. But to the eye the craving for a clear image is an irrepressible instinct; and, as any object approaches, or as the regard is turned from a distant object to a near one, the refractive power is at the same time increased by the effort of the ciliary muscle, and the clear image is still obtained. The same power of internal variation comes into play to prevent the formation of dim images as a result of spherical aberration or of asphericity.[1] The eye adjusts itself involuntarily for the aspect as well as for the distance; and, in the case of a person, for example, whose vision for horizontal and for vertical lines is different, the vertical and the horizontal boundaries of a square are not looked at together, as by a normal eye, but in immediate and alternating succession. In this way the possessor of a defective eye may remain in ignorance of his defect, or may be guided to a knowledge of it only by the fatigue which his constantly varying accommodative efforts will in time occasion.

The influence of the other senses in controlling the impressions received through the eyes is very considerable, but is chiefly exerted at an early period of life, when it may easily escape observation. A child, for example, whose ocular surfaces, like flaws in a window-pane, distort all they look upon, may remain unconscious of his peculiarity. He is told that certain figures are circles, or

[1] [As regards spherical aberration this is not true, neither is it strictly true in the case of asymmetry of the refracting surfaces, for the reason that any change of adjustment which improves the definition of certain details of the image must needs impair the definition of such other details as were previously more distinct.]

squares, or ovals; and he recognizes their identity although he may never see their true outlines. There comes, therefore, to be a general consent about the names of appearances, even though this consent may cover a certain amount of difference in the appearances themselves.

The effect of habit is shown in our ordinary unconsciousness of those impressions upon the nervous system which are being made perpetually. Thus, although the arborescent vessels of the retina stand always between our gaze and outward objects, we remain ignorant of their existence, unless they are brought into view by some new circumstances, or by some unusual method of illumination. In the same way, there are certain permanent defects of vision which people learn to disregard, and by which, as a matter of fact, they are neither inconvenienced nor deceived.

We must therefore lay aside, as an assemblage of pleasant fictions, the belief long taught and entertained that the eye in any way approaches perfection as an optical instrument. Even in its normal construction it is full of faults, which would condemn a telescope or a microscope to be thrown aside as useless; but which, in the living organ, are neutralized by the conditions under which it is exerted, as well as by a variety of physiological compensations. When we step beyond the limits of the normal eye we soon find ourselves in the presence of defects of structure, of shape, of sensibility, or of directing power, which the utmost extent of our physiological compensations fails to correct, and which produce either habitual discomfort or habitual error. The error may perhaps be disregarded, as long as the individual who is the subject of it remains free from distress. But, wherever there is discomfort there is a possible or probable source of disease; and, as a rule, the many people who always feel that they have eyes are walking, more or less unconsciously, on the brink of a precipice over which they may at any time fall. The protection and relief of eyes in which an exaggeration of some ordinary defect overpowers the resources of physiological compensation, and thus, by exciting nervous irritation, muscular pain, or vascular plethora, lays the foundation of morbid action, is an object well worthy of the attention of practitioners. An imperfect organ, if its powers are developed and utilized, and its weaknesses as much as possible considered, will usually last out the lifetime of its possessor; while, if injudiciously or improperly strained, it becomes exposed to dangers from which it cannot be expected altogether to escape.

CHAPTER II.

ON THE EXAMINATION OF THE EYE.

THE transparency of many of the tissues which enter into the formation of the eye, and the accessibility of most of them to various modes of examination, render it easy, generally speaking, for the surgeon to make himself acquainted with the facts of any case of ocular disease or injury which he may be called upon to treat. It is therefore the more necessary, in inquiring into the state of the organ, to utilize in the most complete manner the advantages afforded by its structure and position, and to look at it in such a way, and with such attention and precaution, that nothing which exists may escape notice. Even when the condition of superficial parts conceals those which are more deeply situated, as when an opaque lens or a turbid cornea prevents inspection of the retina, or an effusion of blood into the anterior chamber shuts out the iris and the pupil from view, there are still methods of investigation which afford evidence as conclusive as any which can usually be obtained with regard to the internal structures of the body. Occasional errors of inference and interpretation must, perhaps, be regarded as inevitable; but an error about a matter of fact can scarcely arise excepting from haste or from carelessness. The first words uttered by a patient, or the first glance at his appearance, may often suffice to indicate to a skilled observer the direction of his inquiry, and to confine it within certain definite limits; but while skill has yet to be attained, it is best to follow some settled order of investigation. For this purpose, an anatomical order, proceeding from the superficial to the deeper textures is, perhaps, the most convenient, and is certainly the most likely to insure that nothing shall escape scrutiny. The eyelids will thus come first under observation. It is manifest that they may depart from the healthy state in many ways, by faulty position, by swelling, by redness, or by the condition of their margins or appendages; and it may be seen at once whether they are apparently normal or the seat of one or more of the coarse changes thus indicated. Whenever there is any redness or irritation of the surface of the eyeball, it is not enough to note the absence of coarse eyelid changes, but the state of the margins and of the cilia should be carefully scrutinized. For this purpose it is well to use a magnifying glass of about two inches focal length; and, with its aid, to look closely at the growth and position of the cilia, moving the eyelid a little away from the globe during the examination, so as to let the light fall at different angles from time to

time. By this method it is easy to discover fine semi-transparent ingrowing eyelashes, which it would otherwise be possible to overlook; and in the same way I have more than once found a shed eyelash, which had been carried into one of the lacrymal puncta, arrested in the canaliculus, and retained there to act as a foreign body of the most vexatious kind, its projecting portion tickling the conjunctiva of the globe incessantly. [We once met with a case presenting exactly the appearance of a rather large conjunctival phlyctenula, in which the sole cause was the irritation excited during several days in succession, by the stiff end of an eyelash projecting less than a millimetre from the lower punctum lacrymale.] The margins of both upper and lower lids should be scrutinized in similar fashion; and then the whole surface of the conjunctiva, both palpebral and ocular. In order to examine the conjunctiva of the lower lid, the lid should be drawn firmly down towards the malar bone by the tips of two or three fingers, placed on the skin just above the inferior margin of the orbit. The patient should then look upwards as much as possible, and the lower retro-tarsal fold will be thrown forwards and rendered prominent. [The lower portion of the conjunctival sac may be best exposed in deeply set eyes, by drawing the lower lid a little away from the eyeball, and directing the patient to look downward.—Arlt, *Krankheiten des Auges*, I, p. 2.] In order to see the conjunctiva of the upper lid, a somewhat less simple manœuvre is required; but it is one which is easily learned, and which it is essential to know. The lids being gently closed, the surgeon takes some small slender instrument, a probe, a pen-handle, or an open pencil-case, and places it horizontally along the upper lid, just below the upper margin of the tarsal cartilage; using his right hand for the patient's left eye, and *vice versâ*. A slight pressure against the upper part of the tarsal cartilage inclines its lower margin a little forwards; and this margin is then seized between the thumb and index finger of the disengaged hand, which obtain a light but firm hold of the cilia and of the edge of the lid. The surgeon draws the lower part of the eyelid still more forward, and then with a quick movement turns it upwards round the pencil, which is held immovable, and acts as a fulcrum of rotation. At the moment when the upward turn is given to the lid, the patient, if not already doing so, should be told to look down, and complete eversion will be obtained. The everted lid may be held by the forefinger against the upper margin of the orbit, and the pencil gently withdrawn. This little manœuvre takes many words to describe; but the thing is done in a moment when once a certain knack has been acquired; and this knack consists chiefly in the consentaneous movement of the two hands, and in the selection of the right time for the upward turn. [The important thing is for the patient to look downward, in which act the levator of the upper lid is relaxed.] In patients with lax eyelids, either from weak orbicularis muscles, or from the effect of chronic inflammation, eversion of the upper lid may be accomplished by the index finger and thumb of one hand only;

the right hand being used for the left eye, and *vice versâ.* The tip of the finger, placed on the lid, causes some projection of its lower margin, which is then seized by the opposition of the thumb, and turned over, the finger itself serving as a fulcrum. [This manner of everting the upper lid involves ruder manipulation, and is more painful than that first described.] The lid being everted, its inner surface must be examined; and it must be borne in mind that foreign bodies are especially apt to lodge on this surface, about a line from the inferior margin of the cartilage. The upper cul-de-sac does not admit of being completely everted; although, when the patient looks down, most of it may be brought into view. It is not an uncommon place of retreat for a certain class of foreign bodies, such as fragments of straw, or of the awn of barley; and it may be fully explored by the bent portion of a hair-pin, or by a wire loop set in a handle, such as is commonly used for buttoning gloves. Eversion of the upper lid is never very agreeable to the patient, and it must be understood that it need not be practiced unless there is irritation of the surface of the eye, of such a kind as might be caused by a concealed foreign body, or by the state of the palpebral conjunctiva.[1] The internal surface of the lid is often covered by warty granulations, which are common sources of undue vascular development on the cornea; and in the lower retro-tarsal fold we may find granulations of another kind—the so-called "sago grains," which consist mainly of enlarged lymph follicles.

When there is obvious congestion of the ocular surface, the point chiefly needing inquiry is whether this congestion is limited to the conjunctiva, or extends also to the deeper portions of the globe. Active congestion of the conjunctiva is readily produced by trifling causes; and, if these continue in operation, the congestion soon becomes chronic from mere passive dilatation and loss of tone of the vessels. It may vary in degree, from a mere vascular network, with white interstices, to the production of uniform redness. But congestion limited to the conjunctiva may always be distinguished by the readiness with which the vessels may be momentarily emptied by pressure. If the tip of the index finger is placed against the cutaneous surface of the lower lid, and so used as first to raise it a little towards the cornea and then to make it glide down again over the lower part of the eyeball, the track of digital pressure, if the congestion is only conjunctival, will for an instant be left purely white, quite up to the corneal margin. The vessels refill as the finger passes on, and obliterate its track. But if the congestion reaches deeper parts, as in inflammation of the iris or of the ciliary body, it will involve the fine vascular zone of the sclerotic, which surrounds the corneal margin, and which remains unaffected by pressure. The vessels of this zone are too minute to be individually visible, even when overfilled; but their distension forms around the cornea a pink annulus which is sometimes seen

[1] [It is not safe to omit the examination of the conjunctival surface of the upper lid, even though there may be no marked hyperæmia of the *conjunctiva oculi.*]

through the conjunctival vascularity, and is sometimes obscured by it, but may always be brought to light by the effect of pressure, which then leaves a track that is pink near the cornea, and becomes white at some little distance from its margin. There is yet a third form of congestion, which is passive and subconjunctival, and is dependent upon some impediment to the free exit of venous blood from the interior of the eye. In this form the surface of the sclerotic is traversed by distended and tortuous veins full of dark-colored blood, which may be seen to emerge from the eyeball through openings not very distant from the corneal margin, and to pursue their course backwards. They are chiefly met with in cases of chronic internal inflammation or of increased tension, and are constantly present in fully developed glaucoma. [They constitute also an important diagnostic sign in many cases of intraocular tumor.]

The examination of the eyelids and of the conjunctival sac having been carried as far as may be necessary, attention should next be given to the cornea. The chief characteristics of this membrane are its uniform transparency, and its smooth reflecting surface, which, as a convex mirror, affords an erect but diminutive image of the objects placed in front of it. In the healthy eye, the transparency of the cornea allows us to see the fibrillation and the colors of the iris with perfect distinctness; but it does not follow, because these are concealed, or seen only imperfectly, that the transparency of the cornea is impaired. The iris may be veiled by turbidity of the aqueous humor, due to the presence of blood or inflammatory products in the anterior chamber; and we then judge of the condition of the cornea by its smoothness and reflecting power, and by the presence or absence of vessels running upon it from the conjunctiva. On the other hand, when the cornea itself is turbid, the turbidity is at first seldom uniform over the whole surface, and the more transparent portions will often allow us to see the condition of the aqueous humor and of the iris.

Slight opacities of the cornea, and even foreign bodies, such as pieces of coal or iron, imbedded in its substance, are liable to escape cursory observation by reason of the direction in which the light falls upon them, or because they resemble in color the background of iris or pupil behind them. There are many affections of the eye which it is well to treat by the aid of comparative darkness; but there are none in which it is proper to be content with examinations made under the same circumstances. In order to get the best possible view of the cornea, the patient should be seated facing a good large window admitting plenty of diffuse daylight, but not exposed to the direct rays of the sun. The eye under inspection should not only be turned successively in various directions, but the surgeon should also vary his own point of view; and, in a case admitting of any doubt, should employ two convex lenses, one as a "bull's-eye," to concentrate light upon the parts observed, the other as a magnifier, with which to examine the illuminated surface. Or he may do the same thing by lamplight,

a method which is dignified by the name of "focal illumination," and which is often of the greatest possible value. The sketch in Fig. 7 illustrates the way in which focal illumination is ordinarily practiced, and the position of the lamp and lenses. The former is placed somewhat in front of the patient, and at the side of the eye under examination, and by varying its place, or that of the illuminating lens, the beam of concentrated light is made

FIG. 7.

either to play over the surface of the cornea or to penetrate to the parts below. Messrs. Weiss have lately constructed a lamp (shown in section in Fig. 8), which burns benzoline retained by sponge, has its own "bull's-eye" and reflector, and is so small that it may be carried in the pocket; and this, which may be held in one hand while the magnifying-glass is held in the other, will often be found to afford a very convenient method of illumination. Inspection of the cornea may show that some foreign body is imbedded in it, or that its surface is more or less cloudy, or irregular in shape, or ulcerated, or marked by the cicatrices of former ulcers. It may also be the seat of circumscribed abscess, or of diffused suppuration between its laminæ, or it may be traversed by bloodvessels, arranged sometimes as two crescents, encroaching on its upper and lower margins, sometimes in a fasciculus running to some single point, sometimes distributed more or less evenly over its surface [a vascular condition of the upper part of the cornea should be especially noted as indicating a probable granular condition of the conjunctiva of the upper lid]. All these are conditions to be examined, and to be carefully noted as elements in diagnosis and as guides to treatment.

The parts of the eye which come next under examination are the aqueous humor, the pupillary aperture, and the portion of the

crystalline lens lying immediately behind it. In health the aqueous humor is perfectly transparent, but it may be rendered turbid by the presence of early inflammatory products, of pus, or of blood. Inflammatory products may be evenly diffused throughout the

FIG. 8.

fluid; but pus and blood, unless they fill the anterior chamber completely, necessarily gravitate to its lower portion. In this position pus may be mistaken for a purulent infiltration between the layers of the cornea itself; but such an error would usually imply a careless inspection. The upper boundary of an infiltration is, as a rule, irregular, while that of a collection of pus in the chamber is an even horizontal line, which, when the head is inclined to one side, changes its place, in relation to the walls of the chamber, in such a manner that the surface of the fluid preserves its horizontal direction. [Pus in the anterior chamber is often so tenacious as only very slowly to change its place by gravitation.]

When the cornea and the aqueous humor are both transparent they allow the condition of the iris and of its central aperture, the pupil, to be clearly seen. The chief characteristic of the healthy iris is its lustrous striated surface; the chief characteristics of the healthy pupil are its circular outline and its free mobility. If the iris be in the least dull or discolored, or if the pupil be irregular in shape, or contracted, or sluggish, these are facts on which important inferences may be founded. The lustre of the iris speaks for itself, but the determination of the mobility of the pupil requires care and discrimination. A sluggish pupil will still contract and dilate in unison with its healthy fellow, although not to the same extent; and hence it is necessary to protect from vari-

ations of light the eye which is not being examined. For this purpose it should be closed, and the closed lids should be covered by a towel or handkerchief, folded into a sufficient number of layers to exclude light entirely, and then applied gently but closely by the hand. The eye under examination should not be touched, but only shaded by the hand of the surgeon, so placed as to intercept light as much as possible and then once and again quickly moved aside while the pupil is steadily watched. In a healthy eye so treated the pupil rather slowly dilates under the shadow of the hand, and contracts much more quickly when the shadow is withdrawn. The pupil retains a circular outline while thus changing, and its area, up to the age of about fifty, is of a clear bright black. After fifty the black is usually exchanged for a more or less gray or yellowish tint. Under the influence of morbid action the iris may be dull, or visibly vascular, or studded by nodules of lymph; and the pupil may be sluggish, or altogether fixed, or irregular in outline, contracting and dilating only at certain parts of its circumference, and its area may be more or less occupied by inflammatory products. For the full determination of some of these conditions, and also in order to inspect the crystalline lens, it is often necessary to obtain the action of atropine, which should be applied in the form of a perfectly neutral solution of the sulphate, of the strength of from two to four grains to the ounce of distilled water [In cases in which the iris is normal it is generally practicable fully to dilate the pupil by using a very weak solution of sulphate of atropia. A solution of the strength of one-fifth of a grain to the ounce dilates the pupil nearly to its maximum in about three-quarters of an hour (Donders). One of the minute gelatin wafers of Savory & Moore, said to contain only $\frac{1}{20000}$th of a grain of atropia, will in about an hour dilate the pupil sufficiently for a thorough exploration of the fundus, and with the very great advantage that its effect passes off, in a great measure, in the course of a few hours. Compare page 84.] The lower eyelid being slightly depressed by the finger, a drop of this solution should be left in the lower retro-tarsal fold, near the outer canthus, by means of a glass bottle or dropping-tube, or of a quill pen fashioned into a blunt scoop. The patient should be told not to wipe out the drop, but to be content with drying the cheek if any of the solution should trickle down. When the application has been efficiently made, complete dilatation of all the movable parts of the pupil will be effected in from twenty to thirty minutes, and any adhesions or irregularities of outline will be rendered conspicuous. When the pupil dilates completely, or with a near approach to completeness, it becomes possible by the aid of focal illumination to see deeply into the crystalline lens, and even to recognize morbid growths, or effusions of blood or lymph lying behind it in the vitreous. Opacities of the lens may generally be made out very clearly, their gray or brown color contrasting strongly with the natural aspect of the pupil. For the inspection of parts deeper than the iris, focal illumination is at best a method

supplementary to the use of the ophthalmoscope, an instrument which is in most cases essential to a complete examination, but which will be made the subject of a separate chapter, and to which in this place it is unnecessary further to refer. But without the ophthalmoscope it is possible for any one, who is acquainted with the anatomy of the eye and with the elements of pathology, to make out, by careful looking and by the exercise of common sense, what is the actual condition of all the more superficial parts of the organ.

In order, however, to examine these superficial parts completely, it is important that the patient should be able and willing to assist the surgeon, both by opening the eyes freely, and also by turning them in any required direction But there are some cases, chiefly of affections of the cornea, in which there is so much intolerance of light that the eyes can scarcely be opened at all. The orbicular muscles contract spasmodically, and, if the lids are forcibly separated the eyeballs are rolled upwards by involuntary contraction of the superior recti. A very intelligent and resolute adult may overcome these difficulties; but they mostly occur in persons of lax fibre, both physically and morally, and usually in children, in whom they are often complicated by fear or reluctance If a child has not a great degree of intolerance of light, its fears may perhaps be overcome by a little management, coupled with a careful avoidance of rough handling and of painful local applications. But in many cases it is evident from the first that management will be of no avail, and then we must either remain in ignorance of the actual state of affairs, or must use force, or must have recourse to an anæsthetic. After some experience it is often possible to guess at the actual condition of the eyes with sufficient confidence to prescribe, and it may happen that the treatment thus prescribed will be justified by success. But for the inexperienced, or in a case of manifest severity, or in one which a first prescription has failed to relieve, it is always necessary that the eyes should be fully and fairly seen, lest mischief of a serious character should be in progress. If the difficulty of seeing them arises only from childish fear, the little patient may be made to sit on the knees of a seated attendant, with its back to the surgeon, who must also be seated. The surgeon next lowers the child's body to a horizontal position, with the face upwards, and fixes the head firmly between his knees, while the attendant restrains the arms and legs. The child is then powerless to resist, and the eyelids may usually be separated without much difficulty. In making the attempt, the skin should first be carefully dried, and the lower lid held down towards the malar bone by the tips of the two fingers, while the surgeon, with the finger tips of the disengaged hand, attempts to raise the upper lid by gliding it, so to speak, over the corneal surface, in such a manner as to counteract a tendency to eversion. If the child cries or struggles, or if the orbicularis contracts spasmodically, it is best to wait, with the fingers in position, for a momentary lull in the muscular action, during

which the lids may often be taken by surprise, and the eye completely uncovered. But if the palpebral conjunctiva is much swollen, or if the upper lid tends irresistibly to turn over and conceal the cornea, or if there is any considerable corneal ulceration, it is most prudent to employ a pair of metallic retractors, such as that shown in Fig. 9, which overcome the difficulties of eversion, and which exert no pressure upon the eyeball. If there is much intolerance of light, the superior rectus may contract so strongly that it may still be impossible to see the cornea without an anæsthetic, which should then be given in such a manner as to produce complete muscular relaxation. A spring speculum is next to be inserted between the lids, and the conjunctiva and subconjunctival tissue seized by forceps, so that the eyeball may be gently rotated downwards, and the cornea fully exposed to view. Before the anæsthetic is administered the surgeon should take care to have at hand any instruments or local applications which the case is likely to require, so that he may use them during the period of unconsciousness. [In most cases of photophobia a very moderate degree of anæsthesia by ether or chloroform is sufficient for the perfect examination of the cornea; deep anæsthesia and the use of the spring speculum and forceps are seldom requisite.]

Fig. 9.

In addition to the most careful possible inspection, it is often necessary to ascertain by palpation the degree of tension of the eyeball, since this is liable to vary greatly in many diseased conditions. In order to estimate tension, the patient should be told to look downwards, closing the lids gently; and the surgeon should place the tips of his two index fingers just under the upper margin of the orbit, so that, through the intervening lid, they may rest upon the deepest part of the globe which is accessible One finger-tip is then employed to steady the eye, while the other, by a gentle counter-pressure, exerted and relaxed alternately, ascertains the degree of hardness. Under this manipulation a healthy eye is felt to dimple a little, with a peculiar kind of elastic resistance, which is difficult to describe in words, but which the sense of touch soon learns to recognize, and for which the observer may take one of his own eyes as a standard, always remembering that the physiological condition ad mits of rather wide variations. Hypermetropic eyes, for example, are often less tense than the emmetropic, and these again than the myopic. The thinness, and consequently greater elasticity, of the sclera in children, in women, and in delicate persons generally,

renders their eyes less resisting than those of adults, of men, and of the robust; and a certain limited degree of hardening is not unnatural in old age. Beyond the physiological limits, tension may vary from a condition in which the eyeball is quite soft, so that its shape may be visibly altered by pressure, to a condition in which it feels as hard as a stone. Mr. Bowman, some years ago, proposed to recognize, for descriptive purposes, nine degrees of tension, namely, the normal, four of increase, and four of diminution. Using the capital T as the sign of tension, he wrote Tn. for the normal state, and indicated increase by the *plus* (+), and decrease by the *minus* (—) sign. A possible or almost doubtful increase or diminution was to be indicated by a note of interrogation after the appropriate sign; a positive increase or diminution, by a numeral, 1, 2, or 3, according to the estimated amount of change. It is obvious that such a scale, although useful to any observer as a means of recording his own tactile impressions, is useless for purposes of comparison. The T + 2 of one person might be the T + 1 of a second, or the T + 3 of a third; and the chief value of the notation is as a means of recording progressive changes in the same case, as estimated by the same fingers. Drs. Dor and Monnik have taken infinite pains about the construction of an "ophthalmotonometer," an instrument intended to measure tension with scientific accuracy by mechanical means; the excursion of a needle over a graduated dial marking the resistance of the eyeball to a known amount of pressure. Their instrument confirms results which had previously been arrived at by the sense of touch, expresses these results in numerical form, and is a valuable aid to physiological research. I question, nevertheless, whether it is likely to be useful, or to supersede educated fingers, in judging of tension with a view to the treatment of disease. In cases which occasion doubt, I think it may be remembered, as a general rule, that the tension of the two eyes of any individual will usually be alike originally, unless there is a congenital difference of refraction between them; and that abnormality of tension seldom proceeds with equal steps in both. A difference between the two eyes, therefore and a very small difference may be recognized), should always be regarded with suspicion, and should at least lead to careful and repeated examination. Again, also as a general rule, it may be said that the continuance of abnormal tension is incompatible with the continuance of normal vision; and that, when the sight does not suffer, a somewhat high or low degree of tension may be regarded as not surpassing the physiological limits for the particular eye in question. There is, however, an alteration of vision from tension of which I have seen several examples, and which it would not be difficult to overlook. This is progressively increasing myopia, or short sight; the sclerotic yielding to the pressure from within, and the eyeball becoming elongated, absolutely stretched in the direction of least resistance. As long as the sclerotic yields, the choroid and retina may for a time suffer little injury; but as soon, in such a case, as the sclerotic can yield

no longer, or can no longer yield sufficiently, the ordinary effects of increased tension upon sight will not be slow to display themselves. Apart from these effects, a high degree of tension is generally attended by some displacement of the plane of the iris, by some sluggishness of the pupil, and by diminished sensibility of the surface of the cornea.

Together with the accurate observation of all changes which may have occurred in the eye itself, it is necessary to take account of the several constitutional conditions on which those changes may depend, or with which they may be associated. A familiar example of such relations is furnished by the frequent connection between iritis and rheumatism, or between iritis and syphilis; and there are other diatheses or diseases with which other special forms of eye affection are frequently combined. Thus, cataract is common among diabetic patients; and a certain kind of degeneration of the retina is almost always associated with the forms of renal disease which produce albuminuria;[1] so much so, indeed, that it is often possible correctly to predict the presence of albumen in the urine by ophthalmoscopic examination alone. More than this, we constantly see eye disease in connection with those changes in the general circulation which occur in persons past the middle period of life; in men, when the abandonment of active habits and an increasing addiction to the pleasures of the table have produced corpulence or plethora; in women, at or about the cessation of the catamenia. The suppression of habitual discharges, hæmorrhoidal or otherwise, has often appeared to be an exciting cause of limited choroiditis; and atheroma of the arteries, especially when associated with hypertrophy of the heart, affords a frequent explanation of retinal hæmorrhage. The retina, like the brain, of which it is an offshoot, is liable to be deprived of blood by the plugging of its arteries by emboli; and the influence of syphilis is not limited to the production of iritis, but becomes, both in the acquired and the inherited forms of the malady, a fertile and constantly operating source of mischief. Painful affections of the fifth nerve are often attended by important changes in the ocular nutrition, or may occur alternately with such changes and in manifest relation with them. On these grounds, therefore, it follows that no investigation of the state of an ophthalmic patient is even approximately complete, unless it includes an inquiry into mode of life, diathesis, prior diseases, and the general condition of the bodily functions.

Besides the objective examination of the eyes, and the due consideration of the questions referred to in the preceding paragraph, it is often necessary to determine the precise state of the visual function, and, in connection therewith, the state also of refraction;

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[1] [This association is not so constant as might be inferred from the text: the greater number of cases of Bright's disease go on to a fatal termination without the occurrence of retinal change, and in a small proportion of the cases of apparently well-marked albuminuric retinitis, the renal complication is wanting, or is of another character.]

whether the eye is emmetropic, hypermetropic, or myopic. Until a comparatively recent time, there was no standard by which the acuteness of vision could be measured; and the first well considered attempt in this direction was made by Professor E. Jäger, of Vienna, who published the test-types called after his name. His series extended from No. 1, the equivalent of English

Brilliant

to No. 20, the equivalent of English 8-line

Roman,

and it soon became usual to say, in describing a case, that the patient could read this or that number of Jäger.[1] For the use of the illiterate, a cross (†) and an asterisk (*)[2] of corresponding size were printed with each of the twenty varieties of type; and in this way a considerable approach to exactness was obtained. For precise accuracy, however, something more than Jäger's scale is necessary, inasmuch as the visibility of an object depends not only upon its size, but also upon its distance from the eye; these two elements determining between them the magnitude of the "visual angle," by which the magnitude of the image on the retina, and hence the apparent size of an object, is governed.[3] The visual angle is that formed between two lines drawn from the extremities of an object to the optical centre of the eye—a point lying a little behind the crystalline lens. Thus, in Fig. 10, C being the optical centre of the eye, and A B an object, A C B is the visual angle of that object, and *a b* is the magnitude of its image on the retina. But the smaller object A′ B′, which is nearer

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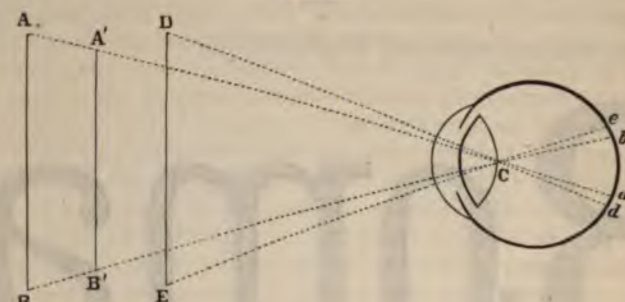
[1] [Before Jäger's publication it was usual to state that a person could read, for example, diamond or pica type. Jäger sought to give a more precise character to such determinations by printing a full series of types which might serve as a universal standard, and in place of the printer's names, which differ in different languages, he gave to each a number. All the value that can be claimed for Jäger's types depends upon the fact, that they have become a common standard; but even this is true of Jäger's own publication only, and does not hold good in the case of the imitations which have appeared in England and in this country. Finally, even in Jäger's types, the German, Greek, and Hebrew texts are only approximately equivalent to the corresponding numbers in Roman type.]

[2] [These signs do not appear in Jäger's types.]

[3] [This principle was fully recognized by Jäger in the construction of his "Strich-Scale" (Staar und Staar Operationen, page 113), which is still unsurpassed for accuracy, and leaves little to be desired on the score of convenience.]

to the eye, is seen under the same visual angle, and forms an image of the same magnitude; while the object D E, which is equal in size to A B, but nearer, is seen under the larger visual angle D C E, and forms the larger retinal image *d e*. In order that the retinal image may excite visual perception, it must be of a certain size,

Fig. 10.



and therefore the object forming it must be seen under a certain visual angle; and it has been experimentally determined that square letters, which have limbs and subdivisions equal in breadth to one-fifth of the height of the letters, and which are so placed that this height is seen under a visual angle of 5′, should be distinctly legible to the normal eye. Dr. Snellen applied this principle to the construction of test-types which give a means of determining the acuteness of vision with exactness. His letters are drawn of the proportions mentioned, as shown in the ex-

Fig. 11.

LXX.

XXX.

amples in Fig. 11, and of various magnitudes—each distinguished by a number which indicates the distance in Paris feet (a Paris foot is a little over twelve inches and three-quarters English) at

which the height of the letter will be seen under a visual angle of 5′, the breadth of its limbs under an angle of 1′, and at which the letter as a whole should be legible. The two examples in the figure are from Nos. LXX and XXX; so that the larger letter should be legible at 70 feet, the smaller at 30 feet—at which distances they would form retinal images of the same magnitude, like the lines A B and A′ B′ in Fig. 10. A person who could not read the smaller letter until it came within three feet would have vision of only one-tenth of the normal acuteness,[1] and would also be able to read the larger letter at seven feet One who could read the smaller letter at ten feet would have vision one-third of the normal acuteness, and would be able to read the larger letter at a distance of seventy feet divided by three—equal to twenty-three feet. Hence the acuteness of vision, usually written V in English, or sometimes S, the initial of the German *Sehschärfe*, is expressed by the distance of the test-letters from the eye, divided by the number of the smallest letter which can be recognized with certainty at that distance; the resulting fraction being reduced to its lowest terms. If the distance be twenty feet, the person who can read letters of No. 20 has $V = \frac{20}{20} = 1$; and this is taken as the normal standard. One who can only read No. 50 has $V = \frac{20}{50}$, or $\frac{2}{5}$ths of the normal. One who can only read No. 100 has $V = \frac{20}{100}$ or $\frac{1}{5}$th, and so on. [It is far better, in recording measurements of visual acuteness, always to give the actual results of the observation rather than to reduce them to any simple fractional expression. Thus, V = 20–LXX, which is to the oculist by no means the exact equivalent of V = 2–VII, or 1–IIIss] In order to use this method in practice, a sheet of test-letters of various sizes should be hung up in a good light, care being taken that the number of the smallest size is a little less than the number of feet in the available distance. In my own consulting-room, for instance, the letters hang at ten feet from the patient's chair, and the sizes range from No. 8 to No. 200, so that I can recognize variations of acuteness ranging from $\frac{10}{8}$, or more than the normal, to $\frac{10}{200}$, or $\frac{1}{20}$th of the normal, and the examination is completed in a moment. Ten, divided by the number of the smallest letter which can be read, gives the result; and this must, of course, be obtained for each eye separately, the patient being told to cover, without pressure, and with the palm of the hand of the same side, the eye which is not being tested. [It is more satisfactory not to cover one eye, but merely to hold a small blackened card obliquely before it, so as to cut off the view of the test-letters only.] For my own use, I have a set of test-types[2] designed by Dr. John Green, of St. Louis, which are better than Snellen's in certain points of detail, but which are not readily

[1] [This is a convenient and common form of statement; but we must not fall into the error of supposing that it is true in a strict mathematical sense. It is perhaps better, in order to avoid giving an erroneous impression, to use the Arabic signs to express the distance in feet at which the test-letters are placed, and to employ the Roman numerals to express the size of the letters actually read, *e.g.*, 20–XL.]

[2] [A set of these types accompanies this edition.]

procurable in this country; while those of Snellen, which fulfil every purpose, may be obtained from any bookseller.

Although V = 1, as tested in the manner described, is generally accepted as the normal standard, yet it must only be regarded as the mean of many observations. Most people under 40 can see somewhat better than this, and the acuteness naturally diminishes with advancing age. Snellen quotes from De Haan an account of the examination of 281 cases, the eyes having been previously ascertained to be of normal refraction and free from disease, and the ages varying from seven to eighty-three years. The results showed that the average acuteness of vision is nearly as follows:

For the age of 10 years,	$\frac{22.5}{20}$
" " 20 "	$\frac{22.5}{20}$
" " 30 "	$\frac{22}{20}$
" " 40 "	$\frac{20.5}{20}$
" " 50 "	$\frac{18}{20}$
" " 60 "	$\frac{14.5}{20}$
" " 70 "	$\frac{13}{20}$
" " 80 "	$\frac{11}{20}$

Within a range of two feet or a little more, the method of testing above laid down would be deceptive in persons over 40 years of age, who were unaided by spectacles, on account of the recession of the near-point which attends the advance of life. It would also be deceptive for people who were merely shortsighted, and who at ten feet might be unable with the naked eye to read anything, although, at ten inches, they might read No. 1 of Jäger with facility. It is therefore convenient to have test types to be held in the hand, and Snellen has published these also, in a convenient pamphlet form, and in several languages, so that vision may be tested in one which is not familiar to the patient, and in which he cannot guess at words from their general appearance, but, in order to read them, must really see the letters of which they are composed. I have found, however, that such a book soon becomes soiled where it is most frequently opened; and Mr. Bellows, of Gloucester, has printed for me, and will supply to others, a very convenient set of types for hand-reading, printed on a single octavo page, which contains eight sizes, and a line of English, of

French, and of German (in Roman type) in each. The letters nearly correspond with those of Jäger's scale, and in using them, it is sufficient to note that such or such a number can be read at so many inches from the eye. Besides the test-types, Snellen and others have designed various dots and angular figures for the use of patients unable to read; and Professor Longmore has introduced, for the army, some black circles on a white ground, which, at stated distances, are equivalent to the regulation targets. Dr. Burchardt, too, under the name of "*Internationale Sehproben*," has published a series of figures formed by groups of circles, which are reproduced by photography in diminishing sizes until they become dots of extreme minuteness, but which do not appear to present any important advantages over the tests previously in use.

When vision is less than $\frac{1}{20}$th, it is easy to obtain a record of it by letting the patient go nearer to the types, but then, in most cases, the power to count fingers affords a sufficient test for all practical purposes. One, two, or three fingers are held between the eye and the window, and the greatest distance at which they can be counted is observed. When fingers cannot be counted, it is no longer usual to speak of vision, but only of perception of light; and this is distinguished as "qualitative" or "quantitative." The person with qualitative perception will see the outline of any bright object, such as a sheet of white paper, when it is presented to him at a favorable angle, and will recognize large dark marks upon it, or perhaps the difference between the margin and the printed part of a page. The person with quantitative perception will distinguish the lighter from the darker parts of a room, or will at least point out the position of a flame, and will know when it is lowered or concealed. When perception of light is lost, the eye is beyond the reach of art, except, perhaps, in the single case of the most acute form of glaucoma, in which vision may occasionally be restored by iridectomy after a short period of total blindness. But the time during which such a result may be possible is to be reckoned by hours only.

Besides the acuteness of vision, it is sometimes necessary to measure also a function which stands in no essential relation with it, namely, the actual sensibility of the eye to light; and Professor Förster, of Breslau, has constructed an ingenious instrument for this purpose. It is a box, a foot long, eight inches broad, and six high, supported on a pedestal. At one end of the box is a peephole, and also a larger opening, covered with oiled paper, through which the flame of a fixed lamp throws light into the interior. Inside are two metal screens, from each of which a V-shaped piece has been cut out, and which meet and overlap each other by turning a screw. The two V-shaped gaps form together a square aperture, which becomes larger or smaller as the screens advance or recede, but which always retains its figure, and ranges in size from one to sixteen hundred square millimetres. Inside the other end of the box is a card, marked with vertical black bars, three inches high and three-quarters of an inch wide, separated by white inter-

spaces of the same size. The patient is kept for a few minutes in a darkened room, and is then told to look in at the peep-hole, the light aperture being at the same time gradually enlarged, until he can distinguish the bars. At present this instrument has hardly come into practical use, but Professor Förster claims for it that it divides cases of impaired vision into two groups, in the first of which the sensibility to light is very little, while in the second it is very considerably diminished. The first group includes such maladies as optic neuritis, retinitis, the retinal degeneration of albuminuria, the hemiopia of cerebral apoplexy, and the impaired sight of alcoholism, in all of which the conducting portions of the visual apparatus, such as the fibrous and ganglionic layers of the retina, the optic nerve as far as the brain, or even the brain itself, are those chiefly affected. The second group includes syphilitic choroiditis and its consequences, pigmentary retinitis, and detachment of the retina, in which the perceptive portions of the visual apparatus are more immediately concerned. Förster proposes to call the sensibility to light L, the minimum of light required by a normal eye h, and the minimum required by a diseased eye H; so that, in any case $L = \frac{h}{H}$. He finds that a normal eye distinguishes the objects in his instrument when h, or the light aperture, is equal to two square millimetres. He therefore takes an opening of this size as unity, and expresses H by half its actual quantity, so as to obtain the value of L in a series of fractions which have 1 for their numerator. Thus, in a normal eye, seeing the objects by the light of an aperture of 2 square millimetres L, $= \frac{h}{H} = \frac{1}{1}$; and, in an eye which required an aperture of 400 square millimetres, $L = \frac{h}{H} = \frac{1}{200}$. It may fairly be conceded that a high value of L would prove the percipient elements of the retina to be in an approximately healthy condition, even though the acuteness of vision was much impaired. Förster cites one case of turbid vitreous, in which the retina could not be seen; but in which the sensibility to light assured him that it had not suffered detachment. This method of examination is one which should receive more attention than has hitherto been bestowed upon it, both with reference to the normal standard and to the variations produced by disease

When vision is subnormal, with no manifest cause of impairment, the next point to be ascertained is the character of the refraction, to some fault of which the defect of sight may possibly be due. In order to determine the refraction, it is necessary to be provided with a set of "test-lenses," which may be obtained from any instrument-maker or optician. The case, as usually sold, contains twenty-two pairs of convex lenses, twenty-two pairs of concave lenses, eight prisms, six slips of cobalt-blue glass of different tints, a slip of red glass, a spectacle-frame with spring clips to hold the lenses for temporary use, and sometimes a set of twelve plano-convex and twelve plano-concave cylindrical lenses.

The special property of a convex lens is that it so bends or re-

fracts the light which passes through it, as to render this light convergent towards a focus or point. [The convex lens bends rays of light passing through it *towards the axis of the pencil;* thus convergent rays are rendered more convergent, parallel rays convergent, and divergent rays either less divergent, parallel, or convergent, according to the power of the lens as compared with the degree of original divergence of the rays.] The degree or the rapidity of the convergence will vary, of course, for any given lens, according to the previous state of the rays of light, whether they were convergent, parallel, or divergent; but the power of a lens is estimated by the distance, expressed in inches, of its focal point for parallel rays. When we speak of a six-inch lens or of a twelve-inch lens, we mean one which will unite parallel rays (*i. e.*, the solar rays, which are approximately parallel) in a point distant six inches or twelve inches from itself; and it is manifest that the six-inch lens, which produces its effect at half the distance required by the other, must be precisely double its strength, and that, in all cases, the greater the focal distance, the less the power of the lens. On this account we do not designate lenses by the numbers of their focal distances, but by the reciprocals of these numbers (*i. e.*, unity divided by them); not as 6 or 12, but as $\frac{1}{6}$ or $\frac{1}{12}$. The whole numbers, which increase as the power of the lens diminishes, although they are used for marking the actual glasses, give an incorrect idea of the relative values of the different members of the series; but the fractions, which diminish as their denominators increase, give the correct values; $\frac{1}{12}$, for example, in the case already cited, being the half of $\frac{1}{6}$, and being the correct expression of the relation which the power of a twelve-inch lens bears to that of a six-inch lens. For the sake of simplicity, instead of writing the word inch, the simple fraction is always used, and is preceded, in the case of a convex lens, by the *plus* sign, so that $+ \frac{1}{6}$ denotes a convex lens of six inches focal length. Concave lenses, on the other hand, act on the rays of light in the opposite manner, by rendering them divergent; and a six-inch concave lens is one which renders parallel rays as much divergent as if they spread out, from a central point six inches distant, to reach the margin of the lens itself. Such a lens, applied to a six-inch convex, would exactly neutralize it, and the two together would be equivalent to a piece of glass with parallel sides. Concave lenses are designated by fractions in the same way as the convex, but with the prefix of the *minus* sign, as $- \frac{1}{6}$ or $- \frac{1}{12}$.

In order to ascertain the state of the refraction, we first cover the eye which is not under examination, and then, taking a weak concave and a weak convex lens, say $+ \frac{1}{60}$ and $- \frac{1}{60}$, hold them in front of the other eye alternately, quickly placing and removing them, the patient still looking at the distant test-types. The two lenses may be taken up at once, between the thumb and index finger, one lens above the other, so that they may be placed before the eye in rapid succession. If the concave improves vision, the patient is myopic; if the convex, he is hypermetropic; and if both

are prejudicial, he may be assumed, with a certain reservation, to be emmetropic. The next step is to determine the degree of myopia or of hypermetropia; and for this purpose, if the case be one of myopia, we try concave lenses in succession, proceeding gradually from the weak to the stronger, until we find that which affords the best distant vision, or which raises V to the highest attainable point. We shall seldom, by any glass, get $V = 1$; but we must get the best result which is attainable. When we have done this, the glass which affords it affords also the measure of the myopia (commonly written "M"). If the glass is $-\frac{1}{6}$ or $-\frac{1}{12}$, we say $M = \frac{1}{6}$, or $M = \frac{1}{12}$.

[$V = 1$ is a sufficiently common condition in uncomplicated myopia: if V falls below unity we should carefully search for complications, such as astigmatism, weakness of the *recti interni*, spasm of accommodation, etc., and, if found, address our treatment to them in the hope that we may thus arrest the progressive tendency of the myopia, or even in some case cure the already existing myopia. In myopia there is danger of over-estimating the extent of the defect, for the reason that myopes often suffer also from accommodative spasm. This is best detected, and at the same time perfectly controlled by the instillation of atropia, which may sometimes be continued with advantage for many days or weeks, during which time the degree of apparent myopia may steadily diminish.]

For hypermetropia, the proceeding would be precisely similar, substituting, of course, convex for concave lenses, were it not that hypermetropia is almost always concealed in part, and sometimes entirely by the action of accommodation The myopic person can do little or nothing for his own relief, and the extent of his defect at once reveals itself. But the hypermetrope can increase the convexity of his crystalline lens by muscular effort; and the instinctive craving for clear images not only leads him to make this effort habitually and involuntarily, but renders him unable wholly to lay it aside. Such an effort is, of course, equivalent to the addition of a convex lens to the eye; and it is said to render part of the hypermetropia *latent*. Thus, if there were hypermetropia (written "H") equal to $\frac{1}{6}$, that is, requiring $+\frac{1}{6}$ for its complete correction, and if the action of the ciliary muscle added to the crystalline lens the equivalent of $+\frac{1}{12}$, that addition would correct half the H, and the best vision would be afforded by a glass lens of $+\frac{1}{12}$ to correct the remainder. This remainder, which the glass lens finds out and corrects, is called the manifest hypermetropia (H *m*), and, added to the latent, it makes up the total (H *t*). Sometimes the ciliary muscle corrects all the H, renders it all latent, so that even the weakest convex lens is prejudicial to vision, and the eye appears to be emmetropic; and in no case can the amount of latent H be estimated with certainty when the eye is in its natural state. This difficulty is overcome by the action of atropine, which, if applied effectually, not only dilates the pupil, but also produces complete temporary paralysis of the ciliary muscle, and thus renders the whole amount of H manifest.

For this purpose it is necessary to use a solution of the sulphate, of not less than four grains to the ounce of distilled water, and to insert a drop between the lids two or three times, at intervals of an hour, the last application two hours before the time of examination. The ciliary muscle will thus be rendered passive, the whole of the H will be made manifest, and the convex lens which gives the best distant vision will be the true measure of the refraction, so that we may say H *totalis* $= \frac{1}{6}$, or $\frac{1}{12}$, as the case may be. [In hypermetropia it is always convenient, but seldom absolutely necessary, to ascertain at once the total defect; in myopia, on the other hand, it is essential to detect and control accommodative spasm at the outset in order to arrest, or possibly to avert, distension of the eyeball. Hence we hold the employment of atropia to be much more important in myopia than in hypermetropia, for in myopia it may enable us to cure or arrest dangerous disease, while in hypermetropia, as a rule, it only helps us to a more speedy diagnosis.] The atropine eliminates an unknown quantity, which would otherwise have defied calculation; but it has the disadvantage of being very inconvenient to the patient, who, even if emmetropic, so that his distant vision remains unaffected, is rendered unable to read without a magnifying-glass for four or five days, and suffers some dazzling from the unwonted dilatation of the pupil. Hence, unless time presses, it is usually best to bring only one eye at once under the influence of the drug, and to let it recover before the second is examined. The application of a wafer of Calabar bean gelatin, two or three times a day, will do something to neutralize the action of the atropine, but not very much, as the latter is the more powerful of the two agents. [The effect of the Calabar bean is often powerful enough to produce contraction in an artificially dilated pupil; but the effect is not so lasting as that of atropia.]

As in myopia, so also in hypermetropia, it is rare, even with the most complete optical correction which can be obtained, to arrive at V = 1. The residual defect is often due, in myopia, to changes in the retina and choroid; and, in hypermetropia, partly to the enlargement of the pupil,[1] partly to the originally imperfect formation of the eye. [In uncomplicated hypermetropia of low grade it is not very uncommon to find V considerably greater than unity, as 16–XII, 16–X, or even in a few cases 16–VIII; in the higher grades, when corrected by appropriate convex glasses, the hypermetropic eye, with its correcting lens placed half an inch or so in front of the cornea, acts like a weak Galilean telescope or opera-glass in increasing the size of the retinal image.] But when, with no manifest disease, the V is much below the normal standard, and especially if the patient is uncertain which of two or three different lenses is the best for him, and does not at once decidedly

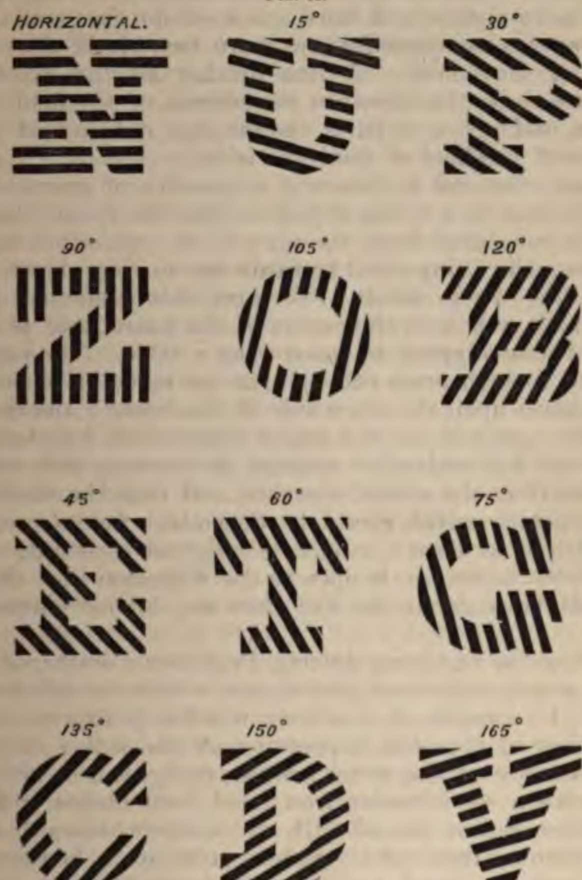
[1] [The author refers, as it would seem, to the artificial dilatation of the pupil resulting from the use of atropia, which he advises in the preceding paragraph As a fact the pupils are ordinarily larger in myopia than in emmetropia or in hypermetropia.]

prefer a certain power to all others, we may suspect the existence of that compound form of ametropia which is called astigmatism. This is a state in which there is an appreciable difference between the curvatures of the cornea in two different meridians—which are often horizontal and vertical—sometimes oblique, but always at right angles to each other. The bowl of a spoon, which is more sharply curved transversely than longitudinally, is a familiar example of an astigmatic surface; and, when the cornea is thus formed, the result is that vision is more defective for lines drawn in certain directions than for others. A patient once complained to me that his sight underwent daily periodical variations of acuteness; and, on inquiring what he meant, I found that his habitual sitting-room commanded a view of a turret clock at some little distance, and that he could see the time at certain hours only. He was astigmatic, and could see the hands of the clock when they were approximately vertical, but lost them when they were approximately horizontal. The forms and degrees of astigmatism are various; for a patient may be emmetropic in one meridian, and either myopic or hypermetropic in that at right angles to it; or he may be either myopic or hypermetropic in both, but in a greater degree in one than in the other; or he may be myopic in one and hypermetropic in the other; while the amount of difference may range from $\frac{1}{40}$ to $\frac{1}{12}$, or even more. It is said that the normal eye is usually in some degree astigmatic, but that a difference of less than $\frac{1}{40}$ is seldom disturbing to vision. In order to determine the fact of astigmatism, we give the patient any figure composed of lines running in different directions. The most convenient test is the set of twelve letters shown in Fig. 12 [published on a separate sheet by William Wood & Co., of New York], which were designed by Dr. Orestes M. Pray, of New York, and may be had, in a size convenient for the consulting-room, from the Autotype Fine Art Company, in Rathbone Place, by whom they have been reproduced at my request. An astigmatic patient, however much he may be aided by an ordinary convex or concave lens, will at once declare, on looking at these letters from a little distance, that the lines in them are of different degrees of distinctness, and further, he will select, as the letters in which the lines are most and least distinct, two in which they are at right angles to each other. If they are most distinct in N, they will be least so in Z, and *vice versâ*. If the lines in all the letters appear equally distinct, or nearly so, the case is not one of astigmatism The manner of determining the form and the degree of this affection, when once its presence has been ascertained, can only be conveniently considered in a subsequent chapter, and in relation to the choice of spectacles for the relief of the attendant visual defect.

Besides the acuteness of vision, it is often necessary to measure the superficial extent of the field, which, in some diseases, becomes concentrically narrowed down within very small limits, while in others it is variously defective, broken, or interrupted. The existence of contraction or defect in the field may generally be dis-

covered by desiring the patient to look steadily at the face of the surgeon, who then moves any small object into different positions, and inquires whether it can be seen in all of them. When this mode of examination renders a defect apparent, it becomes desirable to define its extent with at least an approach to precision.

Fig. 12.



The early attempts at mapping out the field of vision were of a somewhat rude and primitive character. A small white cross was marked on the centre of a black board, which was hung against a wall. The patient was placed with the eye under examination level with this cross, and at a measured distance, of from eight to twelve inches, away from it. He was directed to look steadily at the centre of the cross, which was called the "fixing-point," and the other eye was closed or covered. The operator, armed with a black wand having a white tip, and with a piece of chalk, stood behind or at the side of the patient, and drew the white tip of the

wand slowly along the board, from its margin towards its centre, in successive directions, usually first in a vertical line, next in a horizontal, and then in two lines intermediate between the former ones. The patient was directed to speak as soon as the white tip came into view, and at this point a chalk dot was made on the board. The patient was directed to speak again as soon as the white tip, in its onward movement towards the fixing-point, became *distinctly* visible, and here a second dot was made. When the process was completed, there were two chalk dots on each meridian of movement. A line uniting all the external dots would then show the absolute boundaries of the field of visual perception, and a line uniting the internal dots would show the boundaries of the field of distinct vision.

The maps obtained in this way were often of great value, but the process was open to the objection that the eye of the patient, which was concealed from the view of the operator, was apt to wander from the fixing-point towards the moving object, and thus to vitiate the whole result. To meet this difficulty, Professor Donders made a hole in the centre of the board, and placed it in a vertical frame adapted to stand upon a table. The patient was directed to look through the hole, at the eye of a second person suitably placed upon the other side of the board ; and this second person gave notice if the eye under observation wandered. It is manifest that a considerable amount of accuracy and care would be required from the second observer, and that the method, however occasionally useful, would be dependent for its success upon the presence of at least a moderately skilled assistant. The flat board system, moreover, is open to the objection that the central fixing-point is nearer to the eye than any lateral portion of the surface.

To obviate the foregoing defects, Professor Förster, of Breslau, contrived a very ingenious instrument, which he called the "perimeter." It consists of a strong wooden platform, measuring fifteen inches by nineteen, supporting at one end a double chin-rest, and having at the other a stout, upright, iron pillar. This pillar carries a semicircular iron band, two inches wide and of twelve inches radius, placed with its concavity towards the chin-rest, and turning freely at its middle point on a horizontal axis, so that it can be placed vertically, horizontally, or in any intermediate position. A movable slide, carrying a white spot, travels freely to and fro over the concave face of the band, and is worked by an arrangement of cords and pulleys, set in motion by a winch handle. A rod proceeding from the base of the chin-rest carries a slender stem, which is placed close to the band, which turns freely right or left, and on which slides a small knob of ivory. The chin of the patient is placed on the chin-rest, on the proper side for the eye under examination, and (the other eye being closed) the knob of ivory is used as a fixing-point, and is adjusted at such a distance on the nasal side of the eye examined as to make the middle of the band correspond with the blind spot. The same

fixation being maintained, the band is placed in successive meridians, and the appearance and disappearance of the moving spot, as it travels round the arc, are recorded on a diagram prepared for the purpose. The operator stands behind the arc, opposite to the patient, and is thus able to watch the direction of his eye, and to see that it does not deviate from the fixing-point. The face of the arc is divided into degrees, and its axis carries a circle similarly divided, so that the latitude and longitude of any defect in the field can be observed, and a map of great accuracy can be obtained. The eccentric fixation-point has the advantage of rendering the optic disk, instead of the macula lutea, the centre of the map, which thus corresponds with the ordinary course of an ophthalmoscopic investigation.

The principle of Professor Förster's instrument is perfectly sound, but its details are extremely faulty. It is very large, heavy, cumbrous, and costly; its strings are constantly becoming loose, or twisted, or otherwise out of gear; its chin-rest is too low, the instrument being on a table, for the comfort of the great majority of patients; its fixing-point is too near the eye to be steadily looked at, by persons who are past middle age, without much fatigue of the accommodation; and the superfluous half of its semicircular band is perpetually in the way. After enduring these inconveniences for a certain time, I made an attempt to overcome them, and with the help of Mr. Hawksley produced the perimeter now to be described. Since its appearance I have been made acquainted with some other English and Continental contrivances for the same purpose; but, possibly from parental partiality, my own instrument still appears to me to be the best, as it is certainly the cheapest and the most handy, which has yet been constructed.

It consists, as shown in Fig. 13, of a simple tripod, supporting a hollow stem, A, in which a second stem, B, moves up and down, and can be fixed at any desired height by the screw C. At the top of the stem B, there is a short horizontal axis, D, carrying the quadrant E E′, which turns with great freedom in a complete circle, and can be secured at any point by one turn of a screw which projects from the axis D. On the quadrant is a travelling slide, F, with a white spot; and a second independent axis is inserted in the axis of the quadrant at G, and carries a short tube, in which may be placed a stem to support the fixing-point. The second, or inner axis, makes a complete revolution within the first, without affecting the position of the quadrant, and without being affected by it. At its attached extremity the quadrant terminates in a circular disk, E′, which is graduated into degrees at the back, where a fixed index allows the exact position of the quadrant to be read off. The quadrant is also graduated from ten degrees to ninety on its concave face, so as to show the exact position of the slide. The fixing-point may be either an ivory knob at the end of a wire, or, what is for most purposes better, a small disk with a central perforation, as shown at H, through which the patient looks at an object on the other side of the room, and obtains fixation without

strain of the accommodation and consequent fatigue to the eye. The travelling slide, F, may be made to carry a spot of any color or size that is desired; and a small box under the centre of the tripod contains a selection for this purpose, together with an ivory knob which may sometimes replace the disk H. The slide is also

FIG. 13.

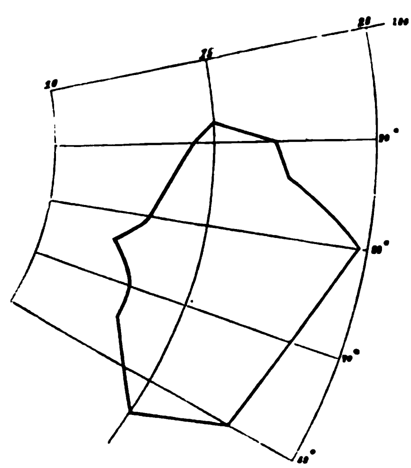
furnished with a ring at the back, by which it may be moved by means of a hook set in a long handle, so that its position may not be pointed out to the patient by that of the hand of the operator. For the purpose of taking exact measurements of the blind spot, the quadrant is graduated at the back, from eight degrees to twenty-five, in degrees and sixths of a degree; and a white dot is placed on the centre of the axis at G, to serve as a fixing-point for this particular purpose.

In order to use the instrument, the patient is comfortably seated in front of a table, with the plane of his face vertical, and with his chin supported by the rest of a demonstrating ophthalmoscope. The perimeter is then set at such a height as to bring the centre of its axis to the level of his eyes, and is placed with this centre exactly opposite the eye to be examined (*i. e.*, an inch and a quarter to the right or left of the median line, according to the eye), and exactly twelve inches distant from it. The patient closes the eye not under examination, and covers it with the hand, resting his elbow upon the table for the sake of insuring steadiness.

In order to measure the blind spot, the smallest white object is fixed to the slide, and the quadrant is raised until it is nearly horizontal, on the temporal side of the eye under examination. The patient is directed to fix the central point G, and the slide is moved from outwards towards the centre, until its white spot disappears

from the patient's view, which it usually does at about 17°. Continuing the same movement, it reappears, say at about 14°; thus giving three degrees as the horizontal width of the blind spot in that meridian. Placing the white spot half way between the two points, at 15½°, the vertical measurement may be taken by raising and lowering the quadrant until the white spot reappears in each direction, usually at the meridians of 90° and 58°. The horizontal and vertical measurements may thus be taken in as many meridians as we desire; and an exact outline of the visual hiatus which corresponds to the blind spot may be traced upon a chart. Fig. 14 shows the kind of chart which is required for this pur-

FIG. 14.



pose, and the irregular line represents the gap in the field which is produced by the blind spot of my own right eye.

In order to measure the entire field, the perforated disk must be used for fixation, and must be so set that, when the patient looks through the hole at a distant point, the centre of the axis may correspond with the centre of the blind spot. For this purpose, in a normal eye, the centre of the opening in the disk should be 10° above the horizontal meridian, and 15½° from the axis, on the nasal side of the eye under examination. The patient is then instructed to look through the hole, the instrument being arranged as before, and the eye not under examination being closed. The operator places the quadrant successively in as many meridians as he thinks fit, and moves the slide from without inwards in each of them until he has completed the circle, marking the limits of perception and of clear vision on a chart as he proceeds. Fig. 15 exhibits two continuous line *circles*, as data, the outer having a radius of 70°, the inner a radius of 10°. The outer dotted line shows the limits of visual perception of my own right eye. The continuous line within the inner circle shows the boundary within

which I can read an unknown letter of Snellen's No. 8 test-types; and the inner dotted line, which exhibits the entire field of vision of a patient with pigmentary retinitis, may serve to illustrate some of the clinical uses of the perimeter. The last two outlines were drawn from the fixing-point as a centre. In mapping the field of vision, it is of course possible to proceed in any order; but there are obvious advantages in pursuing a regular method. I usually

FIG. 15.

commence from zero, with the quadrant vertically downwards, and move it upwards towards the temporal side of the eye under examination The charts may be filled either as maps of the field, by placing the marks in directions corresponding to the positions of the quadrant (*e. g.*, below the centre when the quadrant is downwards); or as maps of the percipient portion of the retina, by placing the marks in contrary directions (*e. g.*, above the centre when the quadrant is downwards). To render them universally intelligible, the same plan should be adopted by all observers; and, of those named, the former is clearly the best, first because it is more simple, secondly, because the maps so drawn will correspond with the inverted ophthalmoscopic image. In all methods of perimetry it is desirable to employ, even for different cases, and more especially for the same case at different times, the same amount of illumination; and this, of course, implies the use of artificial light in a darkened chamber. Even a small diminution of light will decidedly contract the limits of visual perception.

It is sometimes necessary to test the power of recognizing colors, a power which may be either congenitally defective or im-

paired by disease. In determining the fitness of men to be railway servants, or to keep watch on board ship, or to discharge any other duty for which the prompt recognition of the difference between red and green is necessary, the state of the eyes with reference to color perception should always be carefully investigated; and it is believed by some that in certain cases of impaired sight the presence or absence of this perception is important with reference both to diagnosis and prognosis. A variety of ingenious instruments have been devised for testing chromatic vision; but they are chiefly useful, if at all, for purposes of physiological research. The requirements of the surgeon will be fully supplied by a few pieces of red, green, blue, and yellow paper, or by sets of types printed in these several colors.

[Dyed fabrics of silk or wool are far superior, as regards brightness and purity of color, to colored paper, such as can ordinarily be procured. Small pieces of these, cut in different geometrical shapes, or in the form of letters, may be pinned upon larger pieces of black or colored cloth or velvet. All color-tests should be carefully analyzed by the prism before using them, but few of the artificial colors being even approximately pure.]

The methods of examination hitherto described are all of them applicable to each eye singly; but it is often important to inquire whether the natural muscular and visual harmony exists between the two. The eyes, in a state of rest, are normally a little convergent; directed, that is, to some moderately near point in space. [In the state of minimum innervation of the muscles of the eye (*i. e.*, "in a state of rest"), the visual axes are parallel, and directed horizontally forward.—Donders, quoted by Snellen & Landolt—*Graefe und Saemisch; Handbuch*, III, page 229.] But they should both be directed to the same point, should both become equally convergent or divergent as this point recedes or advances, should both turn to the right or left with equal movement, should be always on the same horizontal plane, should be capable of steady fixation at all reasonable distances, and should see only a single image of the thing looked at, whatever its position with regard to them. These conditions may be tested by taking any convenient small object, such as a pencil, and desiring the patient to look at it, and to follow it with his eyes without moving his head, as it is advanced towards him and drawn back, or moved successively in various directions, upwards, downwards, laterally, and obliquely. The most common form of disturbed muscular harmony is that which is familiarly known as squint, which declares its existence without any particular examination, and which requires more detailed consideration than it can receive in this place But there are many varieties of disordered muscular action which are not sufficient to produce obvious or permanent squint, and which only become apparent when the eyes are turned in certain directions. Suppose, for instance, that the left internal rectus had become somewhat weakened. There would be nothing manifestly amiss until the patient attempted to turn "eyes right," when the left

eye would lag behind its fellow, and would thus fall out of proper parallelism. The image of the object looked at would be formed on the yellow spot of the right eye, and on a point on the temporal side of the yellow spot of the left eye, and the two images would no longer be combined. There would be double vision, or diplopia, and the images would be crossed; that of the right eye being referred to the actual position of the object, that of the left eye more or less to the right of this actual position, according to the degree of the defect. In like manner, if the left external rectus were weakened, the left eye would lag behind when both were turned to the left. The right eye would receive the image on its yellow spot, the left eye on the nasal side of its yellow spot, and the diplopia would be no longer crossed, but direct, the right eye seeing the object in its natural position, the left eye seeing it to the left of that position. The most troublesome double vision is that which is associated with very slight deviation, because, when the deviation is considerable, the second image is formed on a peripheral and comparatively insensitive part of the retina, is from the first of small intensity, and may soon be neglected or forgotten, as we see every day in ordinary squint. But when the deviation is only slight, the second image is formed near the yellow spot, on a highly sensitive part of the retina, and may be nearly as intense as the other. [The intensity, as well as the sharpness of definition of the retinal image, is nearly the same in a moderately peripheral as in an accurately central position; it is the perception, rather, which loses in vividness in indirect vision.] Under these circumstances it often causes great distress, even vertigo, and much uncertainty as to the real positions of objects. Sometimes, in such cases, the deviation is so slight that it is difficult to ascertain by inspection which eye is at fault; as, for instance, in double vision on looking to the right, whether the left internal or the right external rectus is the weakened muscle. Such a doubt may be resolved by two methods; first, by ascertaining which eye moves to obtain correct fixation when the object looked at is suddenly concealed from the other; secondly, by ascertaining whether the images are crossed or direct. [These tests are generally sufficient, although, in strictness, they only show which of his eyes the patient habitually uses; this is, as a rule, his *best* eye, and it occasionally happens that in paresis of one of the recti muscles, the eye so affected continues to be used by preference if, at the same time, it happens to be decidedly better than its fellow. We met with a well-marked case of this kind several years ago, and the same thing is noticed by Schweigger, *Handbuch der Speciellen Augenheilkunde*, first edition, page 131.] For example, on looking to the right, if the right eye were lagging behind, it would move towards the object as soon as a screen or the hand was so placed as to conceal that object from the left eye; while, if the screen were so placed as to conceal the object from the right eye, the left, being already properly directed, would make no movement; and again, if the left eye were lagging be-

hind, it would be the one to move under the assigned conditions. With regard to the relative positions of the two images, that which is formed on the yellow spot is generally so much the more intense that it can be readily distinguished from the other; but, if this is not the case, we give a lighted candle as an object of vision, at a distance of eight or ten feet, and cover one eye only with a slip of red glass. The red image, whether it be on the right or left of the other, will of course be that of the eye over which the red glass is applied, and in this way the relative positions of the images can be rendered certain.

There are a few cases, occurring chiefly in myopic persons, or in those whose eyes are congenitally of different refraction, in which deviations do not produce diplopia, because binocular vision has never existed. [In ordinary strabismus, also, the faculty of binocular vision is generally lost very early in the disease; hence double vision is not generally complained of.] The eyes of such people are practically independent organs; and it sometimes happens that one of them is used for near, the other for distant objects. A simple test of the possession of binocular vision is to hold a printed page at a convenient reading distance, and to read it with both eyes. Then, still keeping the eyes fixed on the print, hold a pencil between the eyes and the page, six inches nearer than the latter. If the person trying the experiment has binocular vision, he will see two rather indistinct images of the pencil, neither of which will obstruct his reading by cutting off any word or letter from his view. If he has not binocular vision, or if, having it, he closes one eye, he will see only one image of the pencil, and this, as an opaque object, will obstruct his reading by concealing words or letters in proportion to its size and thickness.

When the sight of one eye is very defective, we may have want of co-ordination without diplopia; and, in such a case, the defective eye usually wanders outwards [if the good eye happens to be hypermetropic the defective eye will probably turn inward], being unrestrained by visual sensations. When the sight of both eyes has been defective from early infancy, as in cases of congenital cataract or of cloudy cornea from purulent ophthalmia, the directing muscles, having never had the guidance of clear images, never acquire their normal tonicity and fixing power. The eyeballs are rendered permanently unsteady, and oscillate in a curious rhythmical fashion which has received the name of nystagmus.

Before leaving the examination of the muscles, it is proper to test the power of the internal recti to maintain convergence. For this purpose the patient is told to fix the gaze upon some small object, which is then brought rapidly to within about four or five inches of the eyes, the surgeon observing whether they remain steadily directed towards it. The object is next screened from one of the eyes by an intervening hand, this eye being still watched over the edge of the hand. If the internal recti are strong, both eyes will remain fixed in the direction of the object; but, if they are comparatively feeble, the eye from which the object is con-

cealed will wander outwards as soon as it loses the visual sensation. The state in which this happens is described as "insufficiency" of the internal recti muscles; and is met with as a not uncommon complication of other forms of disorder. [Other tests for insufficiency of the recti interni are given in Chapter XV.]

CHAPTER III.

THE OPHTHALMOSCOPE AND ITS APPLICATION.

OF the many modern instruments which have been contrived in order to facilitate physical diagnosis, the ophthalmoscope is among the simplest in its construction, and is also among the easiest of management and application. For many ages, it was considered impossible to see into the interior of the eye; and the assumed impossibility long rested on the strange hypothesis that the pigment of the choroid absorbed all the light which entered, and suffered none to return. This hypothesis was disproved by the late Mr. Cumming, who, in 1846, when a student at the London Hospital, showed that, in certain positions of the observer and the person observed, a luminous reflex could be obtained from within the eye. [The same observation was made independently by Brücke, and published in 1847.] Mr. Cumming's premature death prevented him from pursuing his investigations; but, about 1848, the late Mr. Charles Babbage took up the subject as a purely optical problem, and constructed an ophthalmoscope which left little to be desired.[1] He placed it in the hands of an English ophthalmic surgeon, who, unfortunately alike for his own reputation and for the scientific credit of his country, did not perceive the practical value of the means of research thus given to him. Mr. Babbage himself, of course, was not a competent judge in such a matter; and, with the modesty natural to his great genius, he submitted to the adverse verdict pronounced upon his invention, which hence remained almost unknown, and absolutely unutilized.

[1] [It does not appear that Mr. Babbage suggested anything more than a mirror with a hole in it,—a contrivance by which the pupil may be lighted up, as in Cumming's or Brücke's experiment, but which affords a view of the details of the fundus under exceptional conditions only.]

Four years later, in 1851, Professor Helmholtz, then of Königsberg, in the course of his researches in physiological optics, produced the ophthalmoscope which bears his name, and in which the reflecting portion is formed of three plates of unsilvered glass, which afford only an indifferent illumination.[1] He sent this instrument to the late Professor Von Graefe, who, more appreciative than our countryman, at once perceived its probable value, and commenced employing it as a means of research. The defective illumination was soon recognized as a serious fault, and it led Professor Ruete to re-invent Mr. Babbage's original instrument, in which the reflecting portion was made of silvered glass, and the necessary sight-hole was obtained by removing a portion of the silvering. This ophthalmoscope has been ever since in use, and has not been modified in any essential particular. Many observers have had it made to suit their own requirements in points of detail, and have called after their own names the patterns which they have described. But whether the mirror is of silvered glass or of polished metal with a perforation, whether its diameter is one inch or two, whether it is plane, convex, or concave, whether the sight-hole is large or small, whether the handle is long, or short, or wanting, are all of them matters which leave the essential character of Babbage's or Ruete's[2] ophthalmoscope untouched; although upon such as these, and such only, are founded the claims to originality of the many persons whose names (conveniently enough if only for the purpose of differentiation) are attached to the different forms of ophthalmoscope which may be found in shops The number of variations made has been so great that all the possible forms must now have been well-nigh exhausted; and it has been determined empirically, as well as by reflection, which of them is to be preferred for each of the various purposes to which the ophthalmoscope can be applied. Before these matters of detail are considered, and before the characters of a perfect ophthalmoscope are described, it will be well to give a short notice of the general principles which govern the construction of the instrument, and which will lead to

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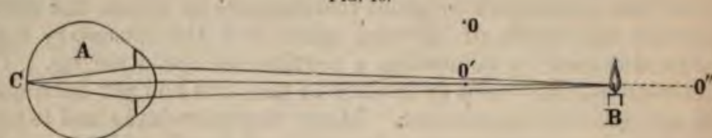
[1] [The ophthalmoscope of Helmholtz is still in many respects the best instrument we possess for examining the fundus by the direct method. The soft and uniform light which it reflects, and at the same time polarizes to a greater extent than any other ophthalmoscope, is generally sufficient to show all the details of the fundus, while it neither dazzles the patient nor provokes contraction of the pupil. The mirror of Helmholtz consists of three superimposed plates of moderately thin glass, but we have long used a mirror with a larger number of plates (six or more) made from the very thin glass used for covering microscopic preparations. The advantages of this modification are a stronger reflection, a more perfect polarization of the reflected light, and a more perfect quenching of the image produced by reflection from the cornea. The thin plates may be packed closely in the frame without the usual intervening rings of paper or tin-foil, taking care only that they are not pressed together so firmly as to develop interference rings.]

[2] [The important feature of Ruete's ophthalmoscope is the use of the convex lens to form an inverted image of the fundus. This does not appear to have been suggested by Mr. Babbage, whose invention, moreover, was not published until two or three years after Helmholtz and Ruete had published full descriptions of their ophthalmoscopes]

a ready comprehension of the qualities which should be required from it in practice.

When the eye is directed to any object, as the eye A, Fig. 16, to the flame at B, it receives all the light which, proceeding from the object, falls within the area of the pupil. By the refractive action of the cornea and the crystalline lens this light is united or brought to a focus upon the retina, as at C. Some of it is absorbed within

Fig. 16.

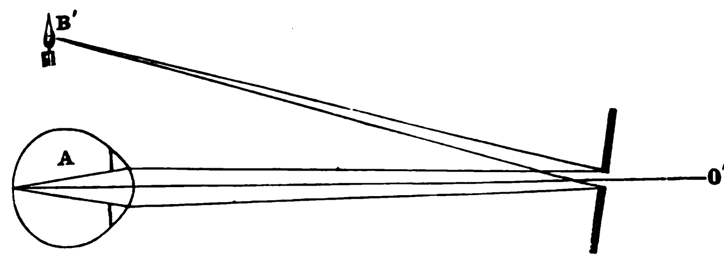


the eye by its internal pigment, and the rest is reflected or returned. But that which is reflected is necessarily subject to the same conditions of refraction as that which entered, and it returns, precisely along the track by which it came, to the point B, from which it started. Hence it follows that an observer, placed at all on one side of the path of the returning rays, as at O, sees nothing which they would reveal, because they cannot enter his eye. If he places himself in the path of the returning rays, nearer to the eye than the flame, as at O′, he places himself also in the path of the entering rays, and intercepts them. He would see if his head were transparent, so that it might permit the entering rays to pass through it. But, as heads are opaque, he cannot be in the position O′ without cutting off the entering rays; that is to say, without cutting off the illumination by which alone he could see anything. The only light received by the eye A would then be that which was reflected from the eye or face of the observer, and this is not sufficient for the object to be attained. Finally, if the observer goes to the position O″, in the path of the returning rays, indeed, but on the further side of the flame, the intervention of the latter overpowers the former, and renders them inadequate to the formation of a definite image. Hence, the ordinary invisibility of the interior of the eye depends solely on this, that the observer cannot receive light from it without placing himself in such a position as to prevent light from reaching it. He cannot see without putting his own head in the way.

The observer remaining in the position O″, in the track of the returning rays, the ophthalmoscope is nothing but a very simple contrivance for taking away the intervening flame B, without taking away that portion of its light which is required. As shown in Fig. 17, the flame is replaced by a mirror with a central perforation, and the flame itself is removed to the position B′. Some of its light then falls upon the mirror, and is reflected by the mirror into the eye A. It returns to the mirror from A, just as if the

mirror itself were the source of light, and part of it will be reflected back to the real source at B′. But the centre of the returning pencil, when it reaches the mirror, falls upon an aperture instead of upon a reflecting surface. It passes through this aperture with its direction unchanged, and enters the eye of the observer at O″.

FIG. 17.



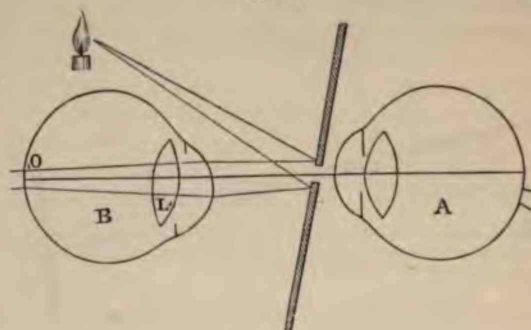
Under these circumstances, supposing the eye of the observer to be immediately behind the mirror aperture, and the mirror to be several inches from the eye of the patient, no details of the interior will be seen. The pupil will appear as an illuminated circle, of a whitish, yellowish, or reddish color, according to conditions hereafter to be described; and the degree of its brightness will depend chiefly upon its size. If it is fully dilated, so as to admit a large amount of light, it will also return a large amount, and will shine with a bright glow. If it is small, or much contracted, the foregoing conditions will be reversed, and the illumination will be comparatively feeble. [In the negro and other dark races the pigment layer of the retina is so opaque as to prevent the return of much light from the general fundus of the eye, even when the pupil is fully dilated; the optic disk, however, being free from pigment, appears strikingly bright by contrast with the dark ground of the eye.]

In order to convert the illuminated circle into a picture of the background of the eye, supposing this to be of normal refraction, one of two methods must be pursued, according as the observer seeks the "virtual" or "erect," or the "actual" or "inverted" image. The former is arrived at by the "direct" method, the latter by the "indirect."

In the "direct" method, the mirror, with the eye of the observer close behind it, is brought very near to the eye of the patient, within about an inch of its cornea; and the observer, looking through the pupil of the patient, sees his optic disk and retinal vessels, or any other structures within his eye, magnified by their own [cornea and] crystalline lens, which then act the part of a simple microscope. The mirror has only the function I have already assigned to it, that of supplying light which the head of

the observer does not intercept; and the relation of the two eyes is shown by the diagram in Fig. 18, in which A represents the eye of the observer, B that of the person observed. It will be per-

FIG. 18.



ceived that the eye A, looking through the mirror aperture, and into the illuminated chamber of the eye B, looks directly at its optic disc O, and sees this in the ordinary way of seeing, except that it is magnified by its [cornea and] crystalline lens.[1] The mirror is merely a means of illumination, and acts in precisely the same way as the common Lieberkuhn of a microscope, by giving to the light a new direction. Everything is seen by the observer in its natural position, or "erect;" and the appearance is not that of an image, properly so called, but of a substantial object; and is hence described as a "virtual" image only.

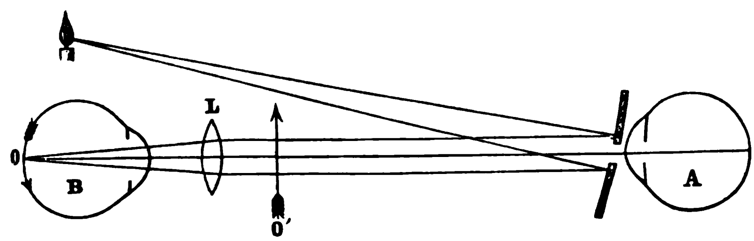
If we hold a common magnifying-glass a few inches away from the eye, and look through it at any moderately distant object, we obtain, as is well known, an inverted image of that object; the thing at which we look appearing diminished and upside down. The inverted image is suspended, so to speak, in the air, between the lens and the eye of the observer, and in the focus of the former; that is to say, removed from it by its own focal length. If we take a sheet of ground-glass, or any other suitable semi-transparent screen, we may discover the precise position of the image by moving the screen to and fro between the eye and the lens. When the screen is either in front of the image or behind it, nothing will be visible except the screen itself; but, as soon as the two occupy the same position, the image will appear distinctly painted upon the screen, and, by measuring the distance of this from the lens, the focal length of the latter may be approximately

[1] [Of the three refracting surfaces of the eye the cornea is by far the most important, inasmuch as the refraction at the surface of the cornea exceeds the sum of the refractions at the two surfaces of the lens. It is inaccurate, therefore, to speak of the lens as the principal or only refracting organ.]

determined. The more powerful the lens, or the shorter its focal length, the smaller will be the inverted image which it forms; so that the magnitude of this image bears an inverse proportion to the magnifying power of the lens when it is used for the examination of near objects.

When a magnifying-glass is held in front of the eye, it produces, in precisely the same way, an inverted image of the parts within the organ; and this is the "actual" or inverted image which, when it is rendered clearly visible by the abundant light supplied for its formation by the ophthalmoscopic mirror, forms the basis of the "indirect" method of examination. The diagram in Fig. 19 shows the positions of the two eyes in this method. A is again

FIG. 19.



the eye of the observer; B, that of the person observed; L is the lens or magnifying-glass, and the eye A no longer sees O, the veritable optic disk of B, but sees O′, an inverted image of O, suspended in the air between A and L. In order to see O′ clearly, the eye A must be at a convenient visual distance from it, such a distance as would be required for reading; and hence the two eyes, instead of being approximated as for the direct method, must be separated by a considerable interval.

Under ordinary circumstances, as we all know, the normal eye cannot see clearly anything which is within one or two inches of it, nor does a magnifying-glass produce an inverted image of a very near object. But, optically speaking, the fundus of the eye is placed, with regard to the observer, in the position of a distant and not in that of a near object, by the interposition of its own [cornea and] crystalline lens. It is the action of [the cornea and] the lens which so modifies the course of the rays of light as to enable the observer to see clearly [and without effort] when the two eyes are approximated in the direct method, which renders the [details of the] erect image invisible [in most cases] when the eyes are too far apart, and which enables the object lens, shown in Fig. 19, to form the inverted image [at or near its focus] in the manner described.[1] To enter into optical considerations would be wholly beyond the scope of the present treatise, and I am therefore compelled to limit myself to this brief statement of facts.

[1] [The words in brackets in this sentence have been introduced by the editor to supply the obvious insufficiency of the author's brief statement.]

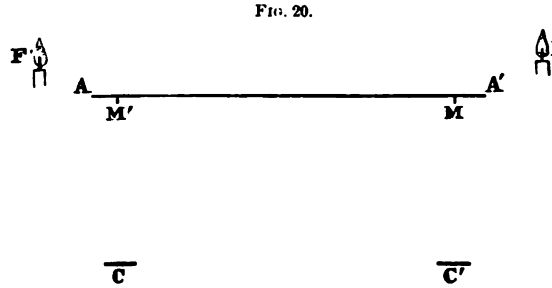
Those who desire further information, with regard to the principles underlying the facts, may obtain it from some of the systematic works upon the subject.

In certain states of the refraction, the erect and inverted images are seen under somewhat different conditions from those already described; and it then becomes important to be able to distinguish them apart by a simple and ready test. Highly myopic eyes yield an inverted image without the interposition of a lens; and hypermetropic eyes yield a well-defined erect image at a greater distance than usual. But, if the head of the observer, or of the patient, be moved a little in any direction whilst the observation is being made, the erect image will appear to move in the same direction as the actual movement, and the inverted image will appear to move in the opposite direction. In this way the true nature of either may be determined at a glance. [The virtual erect image in hypermetropia lies behind the cornea, and continues perfectly visible when the eye of the observer is brought within half an inch of the eye under examination; on the other hand the inverted real image formed in the higher grades of myopia is never less than an inch or two, generally several inches, in front of the cornea, and becomes indistinguishable in its details as the eye of the observer approaches it.]

With this preface, I may proceed to apply to the ophthalmoscope the sound principle that whoever wishes to overcome quickly the practical difficulties of a new art must learn to overcome them one at a time. The first purpose which the ophthalmoscope has to fulfil is that of an illuminator; and the first thing to be acquired in using it is the knack of illuminating the interior of the eye, and of maintaining the illumination unchanged, notwithstanding any change in the relative positions of the patient and the observer, or in the distance by which they are separated. Now this knack may be acquired upon a mask, or a sheet of cardboard, quite as readily as upon a living patient; and, as sudden variations in the illumination are distressing to the human eye, I think some inanimate substitute for it should generally be used by a beginner. When the ophthalmoscope was a new instrument, the gravest fears were entertained, probably in consequence of the sensations connected with dazzling, lest the illumination should be injurious; and many writers seemed not to remember that "to bear light" is the special and peculiar function of the eye. The fears that were so freely expressed have proved to be groundless; for I am not acquainted with a single authenticated instance in which it has been shown that the reflection from the mirror has done harm. Notwithstanding this, sudden changes of light are disagreeable; and they not only occasion distress, but they also lead to spasmodic efforts to close the lids, or to semi-voluntary movements of the head, which at once interfere with the success of the observer, and indicate the discomfort of the person observed. An eye which will bear a complete examination without inconvenience, if the necessary amount of light is directed into the pupil-

lary aperture from beginning to end, will be much distressed if the same degree of illumination is intermittent, flashing into and out of the pupil every second or two. In order to acquire the necessary knack, a good plan is to sit down before a cardboard screen placed upright upon a table, and having a circle, the size of a dilated pupil, marked upon it. This circle should be about two inches from the margin of the screen to the right of the observer, and should be at the height of the observer's eye. A brightly burning lamp, with its flame at the same height, should also be placed on the table, a little behind the screen, so as not to illuminate its surface, and about two or three inches to the right of its margin, in the relative positions shown in Fig. 20, where A A′ represents the line of the screen, M the

FIG. 20.



mark, F the flame, and C′ the chair of the observer. The latter should then take an ophthalmoscope mirror, furnished with a handle, and should hold it in the right hand, close to the right eye [better in the *left* hand, using the *left* eye, and keeping the right eye either open or closed as may be easiest], at such a height that he can see through the aperture, and with the handle vertically downwards. He should keep the other eye open, and should observe the position of the spot of light reflected from the mirror. At first, this spot of light may perhaps play about the room in an uncertain manner, but a few trials will bring it upon the screen, and a few more will fix it upon the circular mark. During all this time the head of the observer must be kept still, and his face should be fourteen or fifteen inches from the surface of the screen. He will find that there are two movements of the mirror; a rotation upon its vertical axis, which turns its right or left hand edge somewhat forward and directs the light right or left along a horizontal line, and a rotation upon a horizontal axis, which directs the light up and down upon a vertical line. By combining these movements, the light may be sent in any desired direction, and may be brought exactly to any spot where it is wanted; it may be fixed upon the mark, or made to play around it. When this has been accomplished, the observer must next notice that, if he is sitting with the mark steadily illuminated, and, moving nothing else, he moves his face two or three inches nearer to the screen, the light will leave the mark and will travel horizontally to the

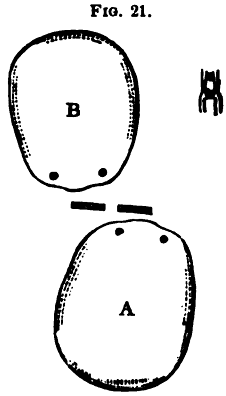
left; while, if he moves his head further from the screen, the reflex will travel to the right. In the former case it can be brought back to the mark by a slight rotation of the left edge of the mirror forwards; in the latter by a corresponding rotation of the right edge forwards. Now in practical work with the ophthalmoscope, to and fro movements of the head are required continually; and the chief point in the art of managing the mirror is to acquire the knack of keeping the rotation and the head movement in unison, so that, as the head comes forward, the left edge of the mirror advances, and, as the head goes backward, the right edge of the mirror advances, in such a manner and degree that the deviations neutralize each other, and the light is kept always on the same spot. The learner must begin by moving his head slowly nearer to and farther from the screen, and must gradually increase both the speed and the extent of this movement; at the same time watching the play of his light through the mirror aperture, as well as with the disengaged eye, and governing his muscles by the sense of sight. As soon as he can illuminate the mark on the screen at pleasure, and can prevent the light from wandering laterally when his head moves backwards and forwards, he is quite ready to begin the examination of patients. It is well to familiarize both eyes and both hands with the mirror, and for this purpose it may be applied to the left eye with the left hand [better with the *right* hand and *right* eye in this position of the screen and flame, M′ representing the right eye of the patient]; and, with the flame in the position F′, the light may be directed from the place C to a second mark on the screen at M′. There are many advantages, in point of convenience, in being able to use the left eye and hand as freely as their fellows.

When perfect mastery of the mirror has been obtained, the learner may at once proceed to examine eyes, choosing first those with pupils dilated. There is an ingenious instrument called Perrin's artificial eye, which at this stage will often be serviceable; but, in using it for the acquirement of dexterity, it is best that it should be fitted into a mask arranged to represent the face. In order to dilate the pupil for ophthalmoscopic purposes atropine is commonly employed, but it is not necessary to have recourse to a very strong solution, or one that will paralyze the accommodation completely. A solution of a fourth of a grain of the sulphate in an ounce of distilled water will be sufficient; and, although it has the disadvantage of acting slowly, so that perhaps forty minutes will elapse before sufficient dilatation of the pupil is obtained, yet this disadvantage is more than counterbalanced by the comparatively transient duration of the effect, and by the way in which it may be neutralized by Calabar bean. A solution of two or four grains to the ounce, such as is commonly employed for therapeutic purposes, or for testing the degree of latent hypermetropia, leaves the accommodation paralyzed for many days, and entails unnecessary inconvenience upon the patient.

The pupil being dilated, and the patient properly placed, with

the lamp on the side of, and a little behind, the eye to be examined, and at the same level with it, the observer should seat himself facing the patient. Supposing the left eye to be the one under examination, and that the erect image is required, the observer should apply the back of the mirror to his own left eye, and should throw the light into that of the patient. He should then approach his face closely to that of the patient, so as to bring the two left cheeks nearly in contact, and the two eyes into the relative positions shown in Fig. 21, which is a diagrammatic section of the two heads and the mirror, B being the head of the patient, A that of the observer, whose left eye will then look directly through the mirror aperture into the left eye of the patient, and will see that portion of its fundus which is illuminated by the reflection from the mirror. The patient must be told to look up and down, right and left, by turns; and the observer must also vary his own point of view, looking into the eye from above, from below, and from either side, until he has seen and scrutinized every part of it—at the same time so varying the inclination of his mirror as to keep the reflection always upon that part of the fundus which is in his own visual line. In order to examine the right eye, the lamp should be placed on the right side of the patient, and the right eye of the observer should be used. The best view is gained when the two corneæ are not more than an inch apart; and at this distance, if the right eye is used for examining the left, or *vice versâ*, the noses and cheeks are apt to come into unpleasant contact, which may always be avoided by the method described above. It is also desirable to fill the chest thoroughly as soon as the eye is illuminated, and to hold the breath during the examination. By doing this the observer neither inhales anything objectionable himself, nor annoys the patient by breathing over him. The knack of seeing the erect image may be very quickly acquired, generally at the first trial; and the structures which are rendered visible are all in their natural positions.

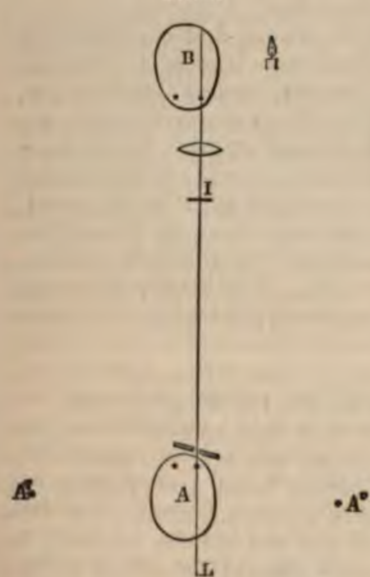
FIG. 21.



In order to obtain the inverted image, the patient and observer should be seated as before, with the lamp in the same position. It is immaterial which eye is used, but it is best to hold the mirror in the right hand for examining the right eye, and *vice versâ*, so as to bring up the object-glass with the other hand, always from the temporal side of the patient, instead of across his nose. The two faces should be opposite each other, and the mirror precisely in line with the eye to be examined, which should be turned a little to its nasal side, about enough to look at the opposite ear of the observer. [In observing the inverted image of the fundus, as in the direct method, it is better to use the right eye in examining the right and *vice versâ*. Thus the patient can see with the eye

not under examination, past the head of the examiner, and look at any distant object as he may be directed. The reasons for looking at a distant object, rather than at a near one, as at the examiner's ear, are that the pupil is less contracted and that the patient is not tempted to follow with his eyes the movements of the examiner's head.] He, when he has illuminated the pupil, instead of moving forward, keeps his face about fifteen inches from that of the patient, and places a convex lens in the line of sight. A two-inch lens is generally used, and it should be held lightly by its margin, between the thumb and forefinger, at about two inches from the patient's cornea. In order to measure the distance, and to keep the lens steady, the tip of the third finger may rest against the margin of the patient's orbit, and may be used, after a little practice, to raise and restrain the upper lid. The lens being in position, the observer should still see through it the illuminated circle of the pupil; but whether he will see details will depend solely upon his distance from the patient, so that if he does not see them he must vary this distance, approaching or receding along the same line until a clear image is obtained, but not making any lateral movement. The lens will form an image in [or quite near] the plane of its own focus; but this image is only visible in the track of the returning rays, and any deviation to the right or left will lose it. The diagram in Fig. 22 shows the position of things; and the observer A must move his head to and fro along the line LB, until he comes to be at the right distance from the image I. If he moves his head to the position A′ or A″, he will lose the image entirely. [Or, rather, he will see the image of that part of the fundus which happens to be in the direction of a line drawn from A′ or A″ through the optical centre of the examined eye.] The whole art of using the ophthalmoscope is comprised in keeping the eye of the observer in a line with that of the patient, in maintaining a steady illumination, and in finding the correct distance.

FIG. 22.



It will sometimes happen that a beginner, when he puts up the convex lens, sees the illuminated pupil occupied by a reflected image, or by two images of his own mirror. These images appear as bright circles, each with a dark central dot corresponding to the perforation. It is said that a mirror image has been mistaken for that of the optic disk; although its exactly circular outline

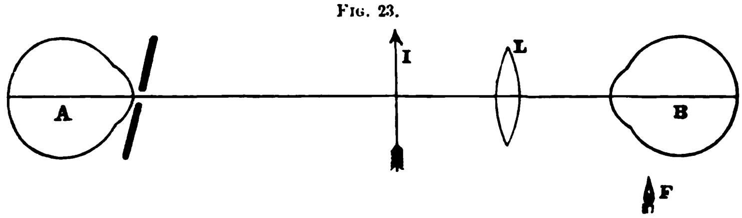
should distinguish it from any natural object Such mirror images are reflected from the two surfaces of the object lens; and they may be separated and got rid of by giving this lens a slightly oblique direction across the line of sight, either from above downwards or laterally.

When an image is obtained, the observer will see the whitish circle of the optic disk itself, or perhaps nothing but clearly defined bloodvessels, crossing a field of somewhat different tint.

If only bloodvessels are seen, the patient must be directed to move his eye [or the observer may change slightly his own position] until the optic disk comes into view, and it may usually be found by tracing the vessels in the direction in which they increase in calibre. If part of it is seen, and if the patient is awkward, and rolls his eye about in an abrupt manner, the rest may often be disclosed without his help by using the prismatic action of the lateral parts of the lens. The lens may be moved a little laterally, or up and down, across the line of sight, and the consequent displacement of the image may accomplish all that is desired.

The proper distance of the observer will depend upon the focal length of the object lens, and upon his own range of vision. I have already said that the lens should be held at [about] its own focal length from the cornea of the patient, and that the image will be formed at [about] the same distance from it on the observer's side. In Fig. 23, let B represent the eye of the patient, L the lens, I the

FIG. 23.

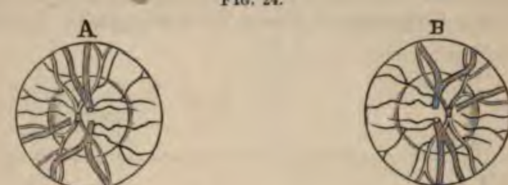


image, A the eye of the observer, and F the flame. If the lens has a focal length of two inches, the distances B L and L I will each be two inches; and if the observer is under middle age, and able to see clearly an object eight inches from his cornea, the distance I A may be eight inches—making a total of twelve inches between the two eyes; in which case the distance F A would also be twelve inches, or only a little more. If the lens were of three inches focal length, the distances B L and L I would each be three inches, and the distances B A and F A ($= 3 + 3 + 8 = 14$), would be fourteen inches. If the observer were past middle age and presbyopic, with a visual distance say of fourteen inches, the distances B A and F A, even with a two-inch object lens ($2 + 2 + 14$) would be eighteen inches. Now the light received from any given source of illumination upon any given surface, diminishes as the square of the distance between them. Hence the mirror, when the distance F A is only twelve inches, will receive, and will send into the eye B, more

light, in the proportion of 9 to 4, than it will receive when the distance F A is eighteen inches. Consequently, as an observer becomes presbyobic, he is obliged to recede so far from the patient that his mirror receives insufficient illumination, and he is unable thoroughly to light up the eye which is under examination. In order to meet this difficulty, he must have recourse to a convex lens, so that he may approach nearer to the image; and this convex lens may either be used as an eye-glass, or may be placed in a clip at the back of the mirror. The one usually sold for the purpose is of twelve inches focal length, which, with an object lens of two inches, will give a total distance of sixteen inches $(2 + 2 + 12)$. This does very well, but by using a still stronger lens behind the mirror the image may be more highly magnified, as well as rendered more bright by the better illumination. I myself prefer to use a seven-inch lens behind the mirror—and thus to obtain a total distance of eleven inches only, which gives an enlargement and a brightness of details nearly comparable to those of the direct method.

In the inverted image, the position of all the parts is reversed, the nasal side of the fundus appearing to be the temporal, the superior to be the inferior, and so on. Fig. 24, A, shows an optic

FIG. 24.



disk as it might appear by the direct method; B, the same disk as seen by the indirect.

Although dilatation of the pupil will much facilitate examination by a learner, it mostly occasions some inconvenience to the patient; and, after a certain amount of practice, it may be dispensed with in many cases. It is obvious that the fundus of the eye will receive a smaller amount of light through a natural or a contracted pupil, and hence that, without atropine, it is necessary to be skilful in the management of the illuminating mirror. It is also necessary that the eye under examination should be turned a little towards the nose before the reflection falls upon it, so that the light may be first received by the insensitive surface of the optic disk. If the patient looks straight to the front, and the light is thrown upon the yellow spot, the immediate contraction of the pupil may be such as to render any examination impossible.

A great number of different forms of ophthalmoscope have been introduced by various makers or practitioners, each generally intended to fulfil some single indication, or to meet some personal

want. The best instrument, on the whole, is that which fulfils the greatest number of indications; and I am inclined to make this claim on behalf of my own model, which is shown of natural size in Fig. 25. In the first instance it has the great merit of lightness and portability, weighing, in its case, with its lenses complete, less than an ounce and a half, and measuring less than three inches by two, so that it can be carried in the waistcoat-pocket without inconvenience.

FIG. 25.

The mirror is concave, of eight inches focal length. It is made of very thin glass, finely silvered on the back, with the silvering removed from a central circle two millimetres in diameter; and it is set in a metal frame, having a central opening, which is countersunk, or bevelled down, so as to present a somewhat funnel-shaped aperture to the eye of the observer, and to facilitate looking through the glass in an oblique direction. At the back of this frame is a clip, holding a small lens of any kind which may be required, and capable of being turned out of the way, as shown in the figure, when it is not wanted.

The proper size of an ophthalmoscopic mirror should be determined by two considerations. It should be large enough to shelter the eye of the observer from the direct light of the lamp; and it should be so small that the diameter of its reflection should not exceed that of the cornea. The iris, lined with dark pigment, is more impervious to light than any other part of the eye; and the only part of the reflex which is useful for ophthalmoscopic purposes is that which passes through the pupil. If a circle of light much exceeding the diameter of the cornea falls upon the eye, some of it will pass through the sclerotic to the retina, and will tend to contract the pupil. Hence the mirror should be as small as possible, subject to the already-mentioned condition that it must be large enough to shelter the eye of the observer. A mirror the size of a silver threepence would afford excellent illumination; but it would be insufficient as a screen. A mirror the size of a shilling is a good medium between extremes. [In ophthalmoscopic examination of the inverted image the diameter of the concave mirror determines only the degree of illumination, and it is generally conceded that with a metallic or silvered mirror and the light of an ordinary Argand lamp or gasburner, a diameter of an inch and an eighth or an inch and a quarter is the most convenient. For direct examinations the central portions only of the mirror are available, and the reflection from the mar-

ginal portions may have some effect in contracting the pupil. If inconvenience is thought to arise from this cause, it is sufficient to cover the marginal portions of the ordinary mirror with dark paper, or a perforated mirror of the size of a silver threepence may be mounted in the centre of a dark disk of the size of a shilling or larger.]

The sight aperture should be as small as may be consistent with perfect vision when the mirror is held obliquely; and after many experiments I fixed upon two millimetres as the best size. If it is smaller than this there is apt to be some blurring of the image by the diffraction of light from the margins of the opening. If it is larger, there is loss of the most important part of the mir-

FIG. 26.

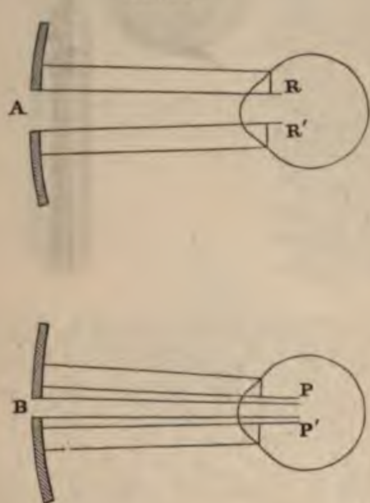
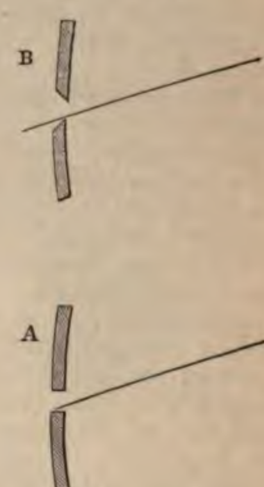


FIG. 27.



ror—the annulus immediately around the perforation, from which alone [in direct examinations] light enters the pupil. In order to obtain an erect image, it is necessary that the inoperative central part of the mirror[1] should be smaller than the pupil; and hence, in order to obtain an erect image without the use of atropine, it is manifest that the size of two millimetres cannot be much exceeded.[2] The thinness of the glass, and the bevelling of the

[1] [The central part of the mirror is by no means "inoperative" when, as in the instrument described in the text, the mirror is of silvered glass with the silvering removed from a small area in its centre. The unsilvered central portion of the glass reflects light enough for a tolerable examination of the fundus even when it is equal in diameter to the full diameter of the pupil.]

[2] [For examination by the direct method Knapp states that a central opening of 3.5 to 3.75 mm. affords the best illumination conjoined with the best view of the fundus.]

opening in the metal frame, are contrivances for preventing the loss of light. I should say they were obvious contrivances, were it not that ophthalmoscopes are still made in which the sight-hole is a sort of tunnel through a considerable thickness of material so that its sides absorb nearly all rays which are not parallel with its axis. Fig. 26, A, shows the illumination through a pupil four millimetres in diameter by a mirror with a sight-hole of the same size, which sends into the pupillary aperture only the rays of light R R′; B shows the illumination through the same pupil by a mirror with a sight-hole of one or two millimetres, which sends the pencils of light P P′. Fig. 27, A, shows the loss, by a "tunnel" sight-hole, of a ray of light which passes freely through the bevelled sight-hole at B. For the indirect method these matters are of less importance, as the mirror is held less obliquely, and its distance from the eye under examination allows light from its lateral portions to be brought to converge upon the pupillary opening.

The lenses which I carry with my ophthalmoscope are a small twelve-inch and a small seven-inch convex, to fit the clip behind the mirror; and two object lenses, one of two and the other of three inches [the addition of a couple of small concave lenses to fit the clip behind the mirror, as in the common form of the ophthalmoscope, known as Liebreich's, would greatly improve this instrument, by rendering it fit for examining the fundus by the direct method in myopia of low and medium grades]. The perfection of the inverted image depends, of course, upon the perfection of the lens which forms it; and therefore my object lenses are made of pebble, which, from its hardness, is not liable to become scratched or damaged even by rough usage. Moreover, my two pebble lenses are united together by a setting, so that each forms a handle for the other, and neither is liable to be accidentally exchanged for a glass lens belonging to some other person.

When the learner has acquired the knack of holding and managing the mirror, it will be a great help to his further progress if he can be shown a perfect view of the fundus of the eye, so that he may afterwards know what to look for, and whether he is seeing aright. For this purpose a variety of demonstrating ophthalmoscopes have been devised, each intended to be so adjusted by a skilled person, that one who is unskilled may be able to look into the instrument as he would into a microscope, and to see the optic nerve and retina. These demonstrating ophthalmoscopes are all designed to show the inverted image, and they all labor under the same serious disadvantage—namely, that although, in studying the inverted image, it is constantly necessary to move the mirror and the lens independently, yet these parts are so connected, by some kind of tube or bar, that the readjustment of one implies the derangement of the other. In some, even the lamp itself is attached to the instrument; and, in others, rods or stems project from the tube, and rest on the forehead of the patient, whose slightest movement will then put everything out of gear. To

obviate these inconveniences, I devised my own demonstrating ophthalmoscope, starting with the principle that every part of it should be absolutely independent of every other part, and capable by itself of quick and easy adjustment. For this purpose the mirror and lens are placed upon separate pedestals; a similar pedestal supports the chin of the patient, and they all stand upon a table which also carries the lamp, and on which they may be moved freely. My first trials with this arrangement satisfied me that it would work better than any other; and also showed that it could be made to afford an image of greater enlargement and brighter illumination than any other. It has already been pointed out that the greater the focal length of the object lens, the greater will be the size of the image; but the limits of enlargement thus attainable by hand-instruments are soon reached, and an object lens of greater focal length than three inches is not available in practice. The object lens gives the best results when it is held at its own focal length from the cornea of the patient, and while this is done it is very desirable that an extended finger should touch his orbit, and thus steady the hand. In this direction, therefore, the focal length of three inches cannot be exceeded; while, on the side of the observer, there is the limit imposed by the length of the arm. A lens cannot be held steadily and comfortably when the arm is fully extended, nor at more than about twenty inches from the eye of the observer; and, if the image is formed much within this distance, there is but little left for his visual range. But by using a table we are rendered independent alike of the steadying finger and of the length of the arm; and may increase the distance between patient and observer almost without limit. I therefore use an object lens of eight inches focal length, which gives a very large image, sixteen inches from the eye of the patient; and I place my mirror forty inches from the eye of the patient, which gives a visual distance of twenty-two [twenty-four] inches for the observer.[1] [In order to obtain sufficient illumination, the lamp is brought up from its usual position, and is placed nearly in the focus of the mirror, while the face of the patient is guarded from direct lamplight by the interposition of a metal screen. For use without atropine, and in order to avoid contraction of the pupil, a plate of glass, slightly tinted with cobalt-blue, is interposed between the flame and the mirror. This filters out, so to speak, the yellow rays, which are the most irri-

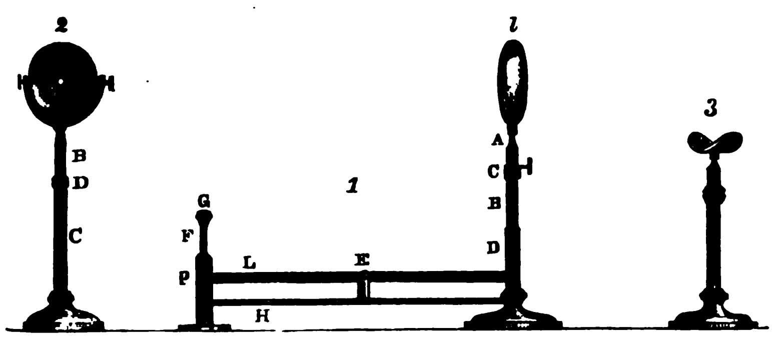
[1] [In Mr. Carter's demonstrating ophthalmoscope the place of the inverted image is very greatly influenced by the refractive condition of the eye under examination. It is only when the examined eye is of normal refraction that the image is formed at the focus of the object lens; in myopia exceeding one-eighth the image lies between the examined eye and the lens; while in hypermetropia the power of the object lens may be inadequate to the formation of an image at any useful distance. This constitutes a serious defect, which may, however, be overcome in a great measure by having stronger object lenses for the different grades of hypermetropia. This ophthalmoscope is probably destined to be of greatest use in delineating ophthalmoscopic appearances and in demonstrations to students.]

tating, and leaves only a soft blue light, which the most sensitive eye can bear without distress [glass "slightly tinted with cobalt-blue" transmits a softer, but at the same time whiter light, than that of the naked flame]. The best, because the whitest and purest light, is that furnished by a Silber Argand burner, consuming either gas or oil; and it should in any case be so arranged as to be capable of adjustment to any height which may be desired [any good burner constructed on the Argand principle will answer].

The instrument, as a whole, consists of the following parts, which are shown separately in Fig. 28.

The lens, Fig 28, 1, is biconvex, four inches in diameter and of eight inches focal length; it is held in a plain ring setting, and is mounted on the column A, which slides freely within the tube B,

FIG. 28.



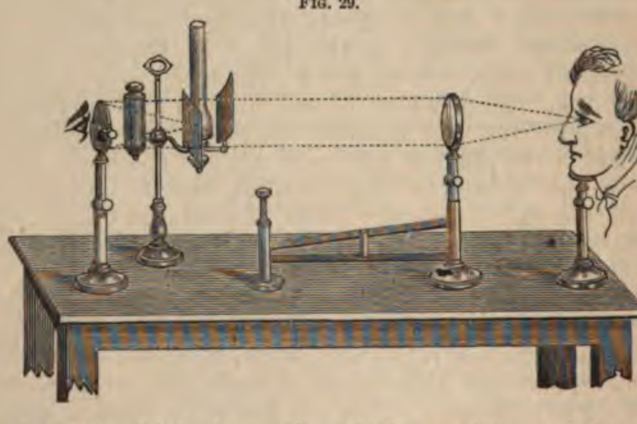
and can be fixed at any point by the screw collar C. The tube B slides within the hollow standard D, and is supported by the lever L. The standard D has a heavy circular foot, which keeps the whole instrument steady. From this foot the handle H, fifteen inches in length, extends to the pillar P. On the upper part of the handle is a short vertical bar E, which serves as a fulcrum for the lever L, one end of which passes through a slit in the standard D, and supports the tube B, while the other end passes through a similar slit in the pillar P, and rests against the lower end of the screw F, which is worked by the milled head G. As this screw is raised or lowered, a contrary effect is produced on the other end of the lever, and the tube B, carrying the lens, is lowered or raised in the standard. When both the column A and the tube B are at their lowest points, the centre of the lens is a foot from the table. The column A has 5½ inches of movement, and the tube B has two inches, so that the centre of the lens can be raised to be 19½ inches from the table, and this range is sufficient for persons of all heights. The column A is free to turn on its vertical axis within the tube B, until it is fixed by the screw collar; but the tube B is furnished with a stud, which projects through a slit in the standard D, and causes B to rise and fall without rotation. The dimen-

sions above given should be carefully observed; since many instruments have been made with the handle too short, or with an insufficient play of rise and fall for the lens—faults which are sources of great inconvenience in practice.

The mirror, Fig. 28, 2, is of glass, concave, four inches in diameter, and thirteen inches in focal length. The silvering is removed from a central circle, three millimetres in diameter. The mirror is mounted in a brass frame and back, the latter having a central aperture seven millimetres in diameter, with bevelled edges. The frame is suspended in a gimbal by two horizontal screws; and the gimbal is supported by the column B, which slides up and down within the standard C, and can be fixed by the screw collar D. The range of movement is six inches, and the centre of the mirror, at its lowest point, is eleven inches above the table. The chin-rest, Fig. 28, 3, is a concave plate of metal, two inches by four, with its corners rounded, and covered with velvet. It is supported on a movable column and standard, like those of the mirror, and ranges in height from nine inches to fifteen. All the foregoing parts should be of a solid and substantial character, with heavy metal feet, and firm joints. The screen is simply a curved sheet of blackened metal, which, as well as the frame to carry the blue glass, may be attached to any gas-burner or oil lamp which is employed. The glass itself should be five inches square, free from flaws, and of a uniform pale tint. For the light, the lamp known as a "reading lamp," but with a Silber burner, is the best; or, if gas be used, a burner fitted with an india-rubber tube may be made to slide up and down upon an upright stem.

Where the instrument is in constant use, it is worth while to have a special table for it; and the manner of its adjustment will be readily understood from Fig. 29, and from the annexed ground

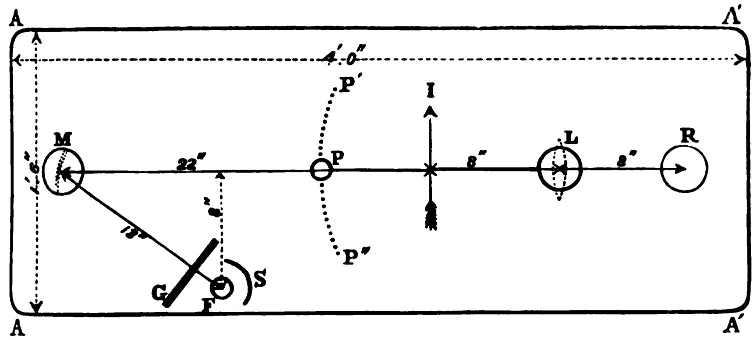
FIG. 29.



plan in Fig. 30, which shows the relative positions of the different parts. In my consulting-room they stand ready in this way. A A′ A′ A is a special table, measuring 4 feet by 18 inches, and 29

inches high. M is the position of the foot of the mirror, and the dotted line crossing the circle shows the degree of obliquity which should be given to the reflecting surface. F is the position of the flame, which may be on either side, S of the screen that cuts off direct light from the patient, and G of the sheet of blue glass. R

FIG. 30.



is the position of the chin-rest, L of the foot of the lens, and P of the pillar at the end of the handle, the dark line showing the position of the handle itself, and the dotted lines across L showing the position of the lens when the handle is thus placed. To render the lens oblique, and to displace mirror images, the pillar P may be moved along the dotted arc, in the direction towards P′ or P″, the foot L remaining stationary. The image will be formed in the position I, eight inches on the observer's side of the lens. In order to use the instrument, the patient seats himself at the end of the table A′ A′, and places his chin on the rest, which must be adjusted to render the plane of the face vertical, the chin being neither tilted up nor depressed. The mirror is then so arranged that its central perforation is nearly level with the patient's pupil; and the lamp, so that its flame is level with the mirror. The latter is then made to throw its reflection upon the patient's face, and he is told to look a little obliquely, thus directing the eye to be examined somewhat towards the nose. The lens is next roughly adjusted by the sliding tube B and screw-collar C, until the circular patch of light into which it converts the mirror reflection comes to be on a level with the patient's eye. The observer then seats himself opposite the patient, at the end of the table A A, looks through the mirror aperture, grasps the handle P of the lens in his right hand, and controls the mirror with his left. He has as much and as ready command of both as in the case of the hand instrument. In order to move the mirror reflex laterally, he rotates the foot of the pedestal with the forefinger and thumb of his left hand. In order to move the reflex upwards or downwards, he turns the mirror on its horizontal axis, either by the margin of the frame or by one of the screws fastening it to

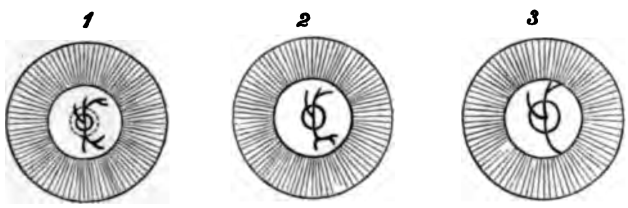
the gimbal. By means of its handle, which is the contrivance of Mr. Foveaux, of the firm of Weiss & Son, he can either move the lens nearer to or farther from the patient, or across the table, so as to shift the observation from one eye to the other, or can render it oblique, or, by the screw, can regulate its height to a millimetre. So quickly and easily may all this be done, that the observer may follow and keep pace with the movements of an unsteady eye, never losing his view of the interior. No assistance is wanted; and the preliminary adjustment, although tedious to describe, does not require a minute for its accomplishment. No other instrument with which I am acquainted is even comparable to this in the size, brilliancy, and clearness of definition of its inverted image; and I have entered thus fully into the details of its construction and management, for the purpose of showing the extreme simplicity of what appears, at first, a somewhat formidable apparatus. The soft blue light, moreover, is scarcely felt as an inconvenience by a patient; and, with even moderate steadiness, the interior of the eye may be exhibited to several persons without distress. From this point of view the instrument is not only highly valuable for the purpose of teaching students, but quite as much so in the consulting-room, for exhibiting morbid changes to practitioners unused to the ophthalmoscope, or even, sometimes, to the friends of patients. Especially where a long-continued or rigorous treatment is required, it is occasionally desirable to afford, to the relatives of the sick person, a convincing ocular demonstration of the existence of the conditions against which the proposed remedies are to be directed.

I have spoken hitherto chiefly of the examination of eyes which are of normal refraction, or emmetropic; and those which are ametropic will be found to present somewhat different appearances; although these do not become very remarkable unless the ametropia is considerable in degreee. In a highly myopic eye, an inverted image may be seen without the intervention of an object lens; and, in a highly hypermetropic eye, an erect image may be seen from a considerable distance. When, therefore, the observer, on first lighting up the pupil with the mirror alone, and while still eight or ten inches or more away from the patient's eye, sees a clearly defined optic nerve or vessels, the patient is either myopic or hypermetropic. If myopic, the image is inverted; if hypermetropic, it is erect; and as already mentioned, the inverted image can be distinguished in a moment, by the simple test that, when the observer moves his eye laterally, the image appears to move in the opposite direction, while the erect image would appear to move in the same direction. When the object lens is interposed, and the inverted image is produced in the ordinary way, the myopic eye presents an apparently extended field, on which the optic disk and vessels appear small; while in the hypermetropic eye the disk and vessels appear larger, and occupy more of the pupillary aperture. The three outlines in Fig. 31 give a diagrammatic view of the inverted image of the same fundus, according as the media in

front of it are myopic (1), emmetropic (2), or hypermetropic (3). In the myopic eye, however, there is a source of error which may sometimes mislead the inexperienced. The optic nerve in myopia is often bordered, and is sometimes even surrounded, by a crescent or an irregularly circular belt of choroidal atrophy, all of which may at first sight seem to be part of the nerve, and may give a deceptive appearance of large surface to the disk. In such cases a careful scrutiny will discover, by a slight difference of color, that the real nerve outline is something of the proportion of the central dark circle in diagram 1, while the dotted line surrounding it may show the extent of the general effect of whiteness.

In the emmetropic eye, not only is no auxiliary lens required for the erect image, but none can be borne;[1] and clear definition is only obtained when the eyes of patient and observer are closely approximated. In the myopic eye, a clearly defined erect image cannot be obtained at any distance, until a concave lens is interposed; and this lens is most conveniently placed behind the mirror.

FIG. 31.



In the hypermetropic eye, as already stated, an erect image can be obtained without a lens, and at some little distance; but when the eyes are closely approximated this image is still clearly seen, and it becomes better defined if an appropriate convex lens is placed behind the mirror.[2] In other words, in order to obtain an erect image of an ametropic eye, the observer must neutralize myopia by a concave lens, and he may neutralize hypermetropia by a convex one. He sees into the eye subject to the same conditions under which the patient sees out of it; and the concave lens which gives him the best defined image of the fundus, or the strongest convex lens with which a clearly defined image is still visible, is that by which the myopia or the manifest hypermetropia of the patient will be corrected. [By ophthalmoscopic measurements with atropine, we obtain the total hypermetropia, and even without atropine we often detect a higher degree than the measure

[1] [This is only true in the case of emmetropia conjoined with absence of accommodation in both patient and observer, as, for instance, when both are fully under the influence of atropia; as a fact, a weak concave lens (say $\frac{1}{24}$ or $\frac{1}{12}$) is a help to most persons in examining emmetropic eyes by the "direct" method.]

[2] [Rather it continues to be seen clearly, and at the same time somewhat magnified, when a neutralizing convex lens is placed behind the hole in the mirror.]

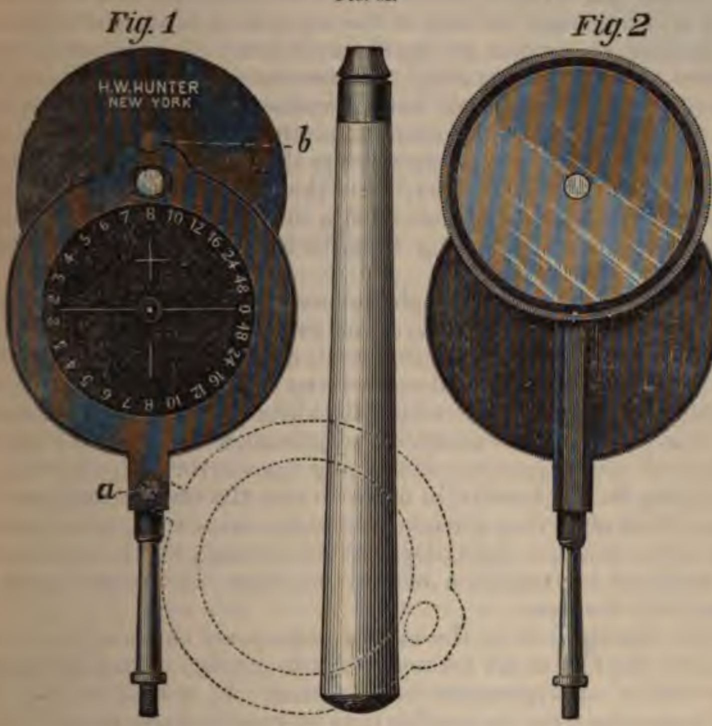
of the *hypermetropia manifesta* as obtained by trials with test-glasses. In other words, a hypermetropic eye under ophthalmoscopic examination, often relaxes its accommodation more than in any act of vision.—See Donders, *Accommodation and Refraction*, Syd. Ed., p. 107.]

In order, therefore, to examine every possible form of eye by the direct method, and especially in order to determine, in every case, the state of refraction with some approach to accuracy, not only with reference to the mere presence of myopia or hypermetropia, but also with reference to the degree of either of these affections, it is necessary to be provided with a sufficient series of convex and concave lenses, of such a size that any one of them may be placed in the clip behind the mirror. The cheap German ophthalmoscopes are supplied with five lenses to be used in this way, one convex, of twelve inches focal length, four concave, respectively of six, eight, ten, and twelve inches. But in these ophthalmoscopes, the size and character of the sight-hole are usually such as to render the mirror scarcely available for the examination of the erect image without dilatation of the pupil; and the series of lenses is too small for the many degrees of ametropia which are met with in practice. Moreover, on account of the inconvenience of carrying a number of loose lenses, and on account of the trouble and loss of time involved in changing them during the examination, the best arrangement is that devised by the optician Rekoss, who fixed a number of lenses in a circular disk, so placed that by its rotation they are brought in succession behind the mirror aperture. One of the most convenient forms of the erect image ophthalmoscope is that of Loring, as shown of natural size in Fig. 32.[1] The mirror is concave, of seven inches focal length, an inch and a quarter in diameter, and with a sight-hole three millimetres in diameter. The sight-hole of the metal frame is bevelled down in the ordinary way; and the revolving disk turns on a pivot near the edge of the mirror, and is secured by a spring catch, which allows it to be removed at pleasure. This disk is provided with twenty-four lenses and one empty aperture, as indicated by the numbers on the back of the disk, giving a series of glasses ranging from convex 2 to concave 2, any one of which may be brought opposite the sight-hole in the mirror by simply turning the disk. The handle is made five inches long, in order that the hand of the observer need never come between his face and that of the patient, so as to interfere with the close approximation of their eyes. A convex lens, of two and a half inches focus, is added to the case, to render the instrument available for the inverted image. I must admit, of course, that this form of ophthalmoscope is superior to my small model, in so far that it is available for every purpose to which an ophthalmoscope can be applied, while the small one is useless for the erect

[1] [We have substituted, in Fig. 32, a new and improved model of Loring's ophthalmoscope for the older form given by Mr Carter, rewriting a part of the description to accord with the changed woodcut.]

image in cases of myopia, or for determining the exact degree of ametropia in any case. These, however, are requirements which are only occasional, and which are almost confined to the consulting-room of the specialist; so that, although I employ and value

FIG. 32.



the erect image instrument for certain purposes, I continue to prefer my own as a pocket companion for daily use.

Besides Loring's ophthalmoscope, several others have been constructed upon the same principle, to meet the wants of particular observers; but I am not aware that they offer any remarkable advantages. In some, instead of mounting the glasses in one disk, two disks are superimposed, so that certain powers are obtained by combinations of lenses. This arrangement is objectionable, on account of the number of reflecting surfaces which then intervene between the patient and the observer. Among recent contrivances, perhaps the best is one made by Mr. Hawksley for Mr. Couper, in which the Rekoss disk and the mirror are so connected that the obliquity of the latter is not communicated to the former, and the observer looks along the axis of any auxiliary lens which he may employ. [This was effected perfectly by Rekoss in his construction of the Helmholtz ophthalmoscope, and again by Strawbridge, who adapted the three disks first used by Loring to Jäger's larger ophthalmoscope. See *Trans. Am. Ophthal. Soc.*, 1871.]

The foregoing observations apply only to an observer who is himself normal-sighted or emmetropic, and an ametropic observer must neutralize his own defect with an appropriate lens, or must allow for it in calculating his results, in order to estimate correctly the ametropia of the person observed. Thus, when both observer and patient are myopic, the concave lens which gives a clear erect image will represent the sum of the myopia of both, and from this sum the known myopia of the observer must be deducted in order to leave that of the patient. Hypermetropia on the part of the observer is less easily dealt with, because its apparent degree will vary with the state of the accommodation; and hence the conclusions of hypermetropic persons about the ametropia of others are seldom entirely trustworthy.[1] In the indirect method, myopic persons may usually dispense with a magnifying lens behind the mirror, their defect allowing them to bring the unaided eye sufficiently near to the image.

The power of using the ophthalmoscope (so far, at least, as to light up the interior of the eye, and to obtain from it a clear erect or inverted image), having been attained, the next thing is to consider the practical applications of the instrument, and the way in which the appearances which it exhibits should be interpreted. For this purpose it is desirable to pursue a regular and orderly method of investigation,—first using the mirror only, or with an amplifying lens behind it, in order to test the transparency of the media; then observing the inverted image, so as to obtain a general view of the fundus; and lastly, the erect image, for the more exact and detailed examination of any changes which the inverted image may disclose.

When the light from the mirror is properly thrown into an eye of which the media are transparent, the pupillary opening appears as a field of uninterrupted illumination. In a healthy eye this field is circular; but its outline may be rendered irregular by iritic adhesions, or by a natural or artificial coloboma of the iris, the result of malformation [or injury], or of iridectomy [or other operation to which the iris may have been subjected]. The point is that, whatever may be the shape of the aperture, the illumination should be unbroken. The degree of brightness will depend, *cæteris paribus*, mainly upon the size of the pupil, because the larger the opening the more light it will receive and return; and the color will depend mainly upon the degree of pigmentation of the retina and choroid, or upon the part of the fundus which is in the line of sight of the observer. In the richly pigmented eyes of dark people the reflection from the fundus will be somewhat of a reddish-brown, while in blue eyes it will be a pale orange; and in either, when the light is returned from the surface of the optic disk itself, it will be whitish; more conspicuously so in dark eyes, from the greater

[1] [A skilled ophthalmoscopist can usually estimate the degree of accommodation he employs, or at any rate, can voluntarily relax his accommodation to a known constant quantity, which can be introduced into the calculation with the same accuracy as the correction for myopia.]

contrast between the nerve color and that of the structures surrounding it. In hypermetropic or highly myopic eyes, some details of the nerve or bloodvessels may be at once apparent; but the observer should place himself at such a distance as to render these details invisible, or at least indistinct, and should concern himself first with the illumination of the field alone. If there be any ity in the media, the illumination will be interrupted by a dark h or patches of corresponding outline. If the opacity is situ- at all deeply in the vitreous, sufficient light may be reflected n it to exhibit its natural color; but if it is in or upon the stalline lens or the cornea, it will appear simply black, like any er opaque object which stops the view of a portion of a bril- ntly illuminated surface. A coin, or medal, or counter, for ex- aple, held between the eye and the globe of a brightly burning mp, in an otherwise darkened room, unless it is very close to the ye, appears simply as a black disk, and neither shows its color, or the material of which it is composed, nor the peculiarities of its surface. The case is the same with opacities in the anterior portion of the eye, of which it should also be said that they appear black only if they are impervious to light, but gray if they are semi-transparent. The chief causes of opacity are: 1. Foreign bodies, which may either be adherent to the surface of the cornea, or imbedded in its structure, or imbedded in the crystalline lens, or may have passed into the vitreous. 2. Scars and nebulæ in the corneal tissue, the result of healed ulcers or of inflammation, and in either case sometimes traversed by vessels which may appear as a darker arborescence within the cloud. 3. The pigmented remains of iritic adhesions, left upon the anterior capsule of the lens, or more rarely upon the posterior surface of the cornea. 4. The various forms and stages of cataract. 5. Flocculi in the vitreous humor, the results of inflammation or hæmorrhage. The nature of an opacity may often be approximately determined, even at a glance, by its outline and its depth within the eye. Thus opacities of the cornea are generally irregular in shape, and fade more or less gradually into the surrounding illumination; while foreign bodies—glass fragments perhaps excepted, unless inflammation has been set up around them—are intensely black and sharply defined. Pigmented spots left by iritis upon the anterior capsule are arranged in a more or less irregular and broken circle, around a clearer central space. The most frequent forms of cataract are concentric with the lens, and are either composed of striæ arranged radially about a centre, or are circular and sharply defined. Flocculi in the vitreous are irregular, seldom sufficiently opaque to appear quite black, and are often independently movable, sinking or floating about when the eye itself is at rest. The depth of an opacity is readily determined by the direction and extent of its changes of position during movements of the eye. This organ being spherical, and turning about a centre of rotation, it follows that all objects in front of that centre will move in the same direction as the cornea, that all objects behind the centre will move in the contrary

direction, and that the distance of the object from the centre will determine the extent of the movement. The appearance shown in Fig. 33 might be produced by an opacity anywhere in front of the retina and in the axis of vision—that is to say, in any of the

Fig. 33.

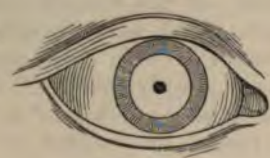
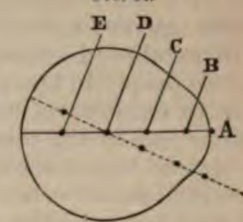


Fig. 34.



positions shown at the points A, B, C, D, and E, in Fig. 34. But manifestly, if the eye were turned downwards, an opacity at A would make a further movement in the same direction than one at B, and this again than one at C, while an opacity at D would remain stationary, and one at E would ascend, as shown by the dotted line in the same figure. A deceptive appearance is sometimes produced when there is one opacity precisely behind another, and both are in front of the centre of the eyeball, as in a case of central corneal opacity with central capsular cataract. The opacity of the cornea descending lower than that of the capsule, the latter will seem to rise from behind the former, and may thus appear to be situated posteriorly to the centre of the eyeball. The same difficulty may occur when a central capsular is complicated by a posterior polar cataract; but in all cases in which there are two points of opacity the observer must take care to notice their actual as well as their relative changes of place, and to correct, if necessary, the results of ophthalmoscopic by the aid of focal illumination

The media being transparent, the observer next interposes the convex object-lens, usually of two inches focal length, and then, as soon as he has discovered the proper distance, the inverted image of the fundus springs clearly into view. As first seen, this should generally include the pale circle of the optic disk, the central arteries and veins as they emerge from or enter the disk, and the annulus of immediately surrounding retina. But by causing the patient to look successively in different directions, the rest of the fundus may be brought into view, nearly as far forward as the equator of the eyeball.

In order to understand the appearances presented, it is only necessary to take into account the formation and arrangement of the structures which may be rendered visible. Excluding, for the moment, the optic disk from consideration, these structures are the retina, the choroid, and the sclerotic; and each of them requires a separate consideration.

The retina, as described in a former chapter, is a translucent membrane, histologically divisible into ten layers, but which may

be practically regarded as consisting of three only; the anterior, containing the nerve fibres and the bloodvessels supported by connective tissue; the middle, containing the perceptive, granular, and ganglionic nervous elements; and the posterior, the layer of pigmented epithelium. The middle layer may be looked upon as an essential part of the eye; the anterior is a mere expansion of the optic nerve within it, necessary, indeed, for the conveyance of visual impressions to the brain, but not otherwise concerned in the act of seeing. The middle and posterior layer cover the whole of the fundus, except the entrance of the optic nerve, and are of nearly uniform thickness, although the distribution of the nerve-elements differs in different parts. The middle layer never becomes an ophthalmoscopic object, its transparency not allowing it to be seen, but only to be seen through.[1] The anterior, or fibrous and vascular layer, passes through an opening in the deeper layers as a bundle of fibres and bloodvessels. The fibres immediately bend round the margin of the opening, and spread radially to the circumference of the retina, while the vessels ramify among and in front of them in an arborescent distribution. Consequently, the anterior layer is thicker, as a mere matter of mechanical aggregation, around the optic nerve entrance than elsewhere, and gradually thins out towards the equator; its vessels, of course, diminishing in size and increasing in number. In health, the anterior layer is rather translucent than [absolutely] transparent. In fair eyes it is invisible from transparency over the greater part of its extent; but even in fair eyes it very perceptibly softens the margin of the optic disk, and may be traced, by careful examination with the erect image, for some little distance beyond it. In very dark eyes it is quite visible as an opalescent film over a considerable surface; and a structure which contains connective tissue and bloodvessels is manifestly liable to be the seat of many changes which may render it conspicuous in disease. Over a small space at the posterior pole of the eyeball, the anterior nervous layers of the retina [all the layers of the retina except the external granular layer and the layer of rods and cones.—Schwalbe, *Graefe und Saemisch*, *Handbuch*, I, I, p. 430] are tinged of a yellow color, and are bevelled off, leaving a pit, the fovea centralis, in which only the percipient layer remains in front of the pigmented epithelium. This "yellow spot," with its fovea centralis, is the centre of direct vision, and the seat of the most acute visual perceptions. Its yellow color is concealed, in ophthalmoscopic examination, by the darker background on which it rests; but its transparency allows the color of this background to be seen more plainly than elsewhere; and the absence of the anterior layers renders it exempt from visible morbid changes. Taken as a whole, the normal retina, although its presence may be discovered by careful inspection, is not a conspicuous structure, and

[1] [This is true in health only; in disease of the retina these layers may become the seat of conspicuous changes.]

may easily be overlooked by a careless observer. Its arborescent vessels, however, are always conspicuous, because they are always different in color from the background, whether fair or dark, over which they ramify, and because their branching arrangement is different from that of the choroidal vessels behind them. The central artery of the retina is a branch of the ophthalmic artery, and pierces the sheath of the optic nerve at a short distance behind the eyeball. It then passes forwards with the nerve-fibres, and usually divides into two main branches, either external to the eye or upon the surface of the disk. These branches accompany the nerve-fibres, and pursue a course upwards and downwards, bending in bold curves towards the temporal side, giving off twigs on both sides as they proceed, and finally ramifying over the whole retina except the yellow spot, in which region the absence of connective tissue necessarily implies the absence of bloodvessels. The veins pursue a course corresponding to that of the arteries, and are readily distinguishable from them by their darker color and somewhat larger size. The larger vessels of both kinds, under certain conditions of illumination, display each a central white [bright] line, which produces the effect of a white [light] stripe, bordered on either side by a red one. This phenomenon has been differently explained by different observers; but it is probably due to the reflection of light from the most prominent part of the surface of the vessel.[1] Besides this, the larger vessels sometimes present faint white lines along their boundaries, manifestly coarse bundles of connective tissue. Both in the veins and arteries, beyond the limits of the disk, the flow of blood, under normal conditions, is continuous and uninterrupted.

Behind the nervous elements of the retina, the tenth or epithelial layer, consisting of accurately fitting hexagonal cells, which are normally crowded with pigment granules, forms in its natural state a barrier which shuts out the choroid from view and is itself the background of the ophthalmoscopic picture. The color of this barrier is partly derived from its own pigmentation, partly from that of the vascular membrane behind it, the details of which it conceals; and it presents a finely granular or stippled aspect, which cannot be well seen except by the direct method. Immediately behind this epithelium is the chorio-capillaris, or finest vascular layer of the choroid, and behind this are layers of larger vessels, including the venæ vorticosæ, lying in a stroma the meshes and interstices of which, except in very fair persons, are occupied by a pigment resembling that of the epithelial cells.

[1] [The fact that the light streak is not white, but distinctly yellow, orange, or even reddish, would seem to prove that the rays of light producing it have passed through a colored medium, such as the blood contained within the vessel. This fact points either to the posterior wall of the vessel, or to some cylindrical surface immediately behind the vessel and concentric with it, as the reflecting surface. Moreover the light streak appears much the same in color and brightness, whether in a part of the vessel lying upon the nearly white background of the optic disk, the red of the fundus generally, or the dark-red of a large vein where it happens to cross the direction of an artery on a deeper plane.]

In the eyes of albinoes, which are wholly devoid of pigment, and even in the eyes of some fair people, in which pigment is very scanty, the epithelial layer and the choroid are transparent; so that, behind the ramifying vessels of the retina, the observer sees a thick network of other vessels of a totally different distribution; and, through the meshes of this network, sees here and there the gleam of the white sclerotic behind it. But under ordinary circumstances the choroidal stroma is so loaded with pigment that it is not even translucent, and the very presence of its vascular structure is concealed from view by the interposed pavement epithelium mentioned, which, when its cells contain the amount of pigment commonly associated even with brown hair, is opaque, and forms a background through which nothing more can be seen, and against which the retinal vessels are conspicuous by their color alone. Towards the decline of life, however, and also in some forms of disease, it not unfrequently happens that the pigment disappears from the epithelial layer, or even that the cells composing this layer become disorganized; and in either case the vessels of the choroid are rendered visible. They present the appearance of nearly parallel red lines, usually separated by pigmented interspaces of about their own width; so that the general effect is that of a sort of striping of red and brown bars, which cannot for a moment be confounded with the branching vessels of the retina. If the stroma pigment of the choroid should itself be removed, then the spaces between the vessels will be white, from the background of sclerotic which is exposed; and if the choroidal vessels are wasted, only a bright white surface, still perhaps crossed by the vessels of the retina, will be left. Such spaces are often bordered by black margins, the result of pigmentary accumulations around centres of morbid action.

It follows from the foregoing considerations that the seat of any morbid change in the fundus of the eye may generally be readily determined. A patch of effusion or of hæmorrhage, for instance, if it is situated in the retina, obscures the retinal vessels, while, if it is posterior to them in the choroid, they may be traced over it in unbroken continuity. Before the retina itself can be rendered very visible, it must undergo alterations which will generally conceal even the color of the deeper parts; and, as such changes cannot affect the region of the yellow spot, the choroid will at this point show through with unusual distinctness. The color of the choroid, varying in depth from orange to chocolate, may always be seen through a healthy retina; but, except in pigmentless [or very light] eyes, its structure cannot be seen until the pigmentation of the epithelial layer has been removed. Again, with the same exception, the color of the sclerotic cannot be seen until the pigment of the choroidal stroma has been removed; and large spaces of sclerotic cannot be seen until atrophy of the choroidal vessels has followed the absorption of the coloring-matter naturally surrounding them.

Proceeding now to the optic disk itself, we have here a combination of structures which may vary greatly in their arrangement within physiological limits, the variations being attended by marked differences of aspect. The optic nerve, in its course along the orbit, is covered by two sheaths, which have between them an interspace, containing only a little lax cellular tissue, and directly continuous with the cavity of the arachnoid. On reaching the sclerotic these sheaths become blended with that membrane, and the nerve, with the central vessels of the retina, enters the eye through a foramen or channel in the sclerotic, which is somewhat funnel-shaped, or wider posteriorly than anteriorly. On a level with the posterior aspect of the sclerotic, the channel is partially closed by a perforated diaphragm of white fibrous tissue, the lamina cribrosa, which intercepts, so to speak, the coarser interstitial connective tissue of the nerve, and suffers only the nerve-tubules and the bloodvessels, with some fine connective-tissue elements, to pass through. Immediately anterior to the sclerotic foramen, and of a diameter equal to that of its internal or anterior opening, is the choroidal foramen, and the margin of this choroidal foramen is often loaded, at parts or in its entire circumference, with black pigment. The fibres of the optic nerve pass through the channel formed by the two openings, and immediately curve boldly round the margin of the choroidal opening, and spread out in all directions, to constitute the anterior layer of the retina, in a manner which has been aptly compared to the curving of a convolvulus flower or of the mouth of a trumpet, and which is shown diagrammatically in Fig. 35. It is manifest that, if an observer were placed a little obliquely with regard to the opening, and if the nerve-tissue were absolutely transparent, he would see on one side, within the dark or black boundary of the choroidal foramen, a white line indicating the side of the sclerotic channel, as at the point A in the diagram; where, however, the character of this channel is altered and exaggerated for the sake of distinctness.[1] From the position of the nerve-entrance on the nasal side of the posterior pole of the eyeball, it only comes opposite the pupil when the cornea is turned somewhat to this side of the median line, and hence the supposed condition of obliquity is fulfilled, and one side of the sclerotic channel is brought naturally into view.

FIG. 35.

The nerve-substance being not absolutely transparent, but translucent only, and that in different degrees in different eyes, accord-

[1] [This diagram, Fig. 35, is altogether incorrect in drawing, showing as it does the anterior opening of the sclera larger than the posterior, which is the reverse of the truth; with this explanation, however, it sufficiently illustrates the appearance in question.]

ing to the state of its capillary circulation and the quantity of its connective tissue, it follows that the distinctness of the side of the sclerotic channel will be more or less concealed or damped, according to the actual quantity and the vascular supply of the nerve-tubules which pass over its margin. Hence, while in the healthy state the sclerotic margin is often concealed, or at least ill-defined, and is only faintly visible as a dim white line bordering the nasal side of the nerve-entrance, it becomes more conspicuous in capillary anæmia of the disk, and more conspicuous still, often as a complete circle of almost tendinous whiteness, when the nerve-tubules are thinned and wasted by atrophy. The choroidal margin, which surrounds the sclerotic margin, is a simple perforation through a comparatively thin tissue, the dark color of which renders it always sharply defined. As already stated, it is often bordered, partly or entirely, by an accumulation of pigment, so that a black crescent lying against one side of the disk, or a black circle surrounding it, is a common physiological phenomenon. The appearances presented by the surface of the disk itself will depend almost entirely upon the anatomical arrangement of the nerve-tubules. If they commence to separate at or behind the plane of the lamina cribrosa, and radiate symmetrically in all directions, the lamina will be exposed in the centre of the disk and will be concealed at its margins. There will then be a central depression of shining whiteness, dotted with a darker stippling indicating the perforations, and surrounded by a ring of nerve-tissue of a comparatively pinky or roseate hue. But if the distribution of the nerve-tissue should be unsymmetrical, the lamina may no longer be visible in the centre: if, for example, the tubules are massed to one side of the opening, the lamina will be displayed on the other; and if, as sometimes happens, the tubules enter the eye in a parallel bundle and only bend at a right angle when they reach the level of the retina, the lamina may be concealed entirely. The symmetrical distribution with a small central opening (the *porus opticus* of some writers is the most common; but an important and not unfrequent variation is that in which the central opening is larger than usual, the nerve-tubules being compressed, so to speak, into a narrow ring around it. This constitutes a "physiological excavation," and it is distinguished by the presence of the ring of nerve-tissue, however narrow this may be, between the sclerotic margin and the edge of the pit. The pathological excavation, to which reference will be made in the chapter on Glaucoma, extends quite up to the sclerotic margin in every case.

Besides the variable degree in which the lamina cribrosa may be concealed by nerve-tissue, another element of variety in the aspects of the optic disk is the variable distribution and course of the bloodvessels. The central artery of the retina may pass through the opening in the tunics of the eye as a single trunk, and may bifurcate and subdivide upon the disk; or it may enter as two, three, or more branches. The trunk, or the branches into which it has divided, may enter through a central "porus opticus,"

down which they may be visible to the lamina cribrosa, or they may be concealed by the nerve-fibres packed round them, or they may enter at the margin of the disk. With regard to course, they may find their way to the surface of the retina either by bold curves or by sharp angles, the latter being usually associated with a physiological excavation, and being rendered conspicuous by a dilatation at each bend, more especially in the veins, where the flow of blood is somewhat retarded. But in the healthy state the course of the vessels across the actual margin of the disk is always straight, and their continuations upon the retina are curved in bold curves only, and are never sinuous or serpentine—conditions which only arise from impeded circulation, although they often remain when the impediment itself has passed away. On the whole, the physiological variations of the disk, although numerous, are of such a character that their nature may be easily recognized by any one who brings thought to the aid of observation. The learner will only find it necessary to call to mind the several structures which are before him, the various ways in which they may be arranged or combined, and the various appearances which the different combinations would be calculated to produce. It must also be remembered that the inverted image affords no clue to the magnitude, and that the apparent size of the disk and of its vessels will be mainly governed by the refraction of the eye containing them. With regard to color, moreover, it is easy to be deceived. Much will depend upon the quality of the light employed, and something upon its intensity. A flame with too much yellow is very deceptive; and too great a glare will drown slight differences. In order to judge of color correctly, it is necessary to use the erect image and a comparatively feeble illumination with white light, such as that yielded by a Silber burner;[1] and it is also necessary to bear in mind the effects of contrast. The faint roseate or reddish-gray tint of the nerve-tissue is most manifest in light eyes with scanty choroidal pigment, and the same color would seem white when encircled by the dark choroid of a brunette. Beginners are curiously liable to guess at the presence of "white atrophy" in healthy optic nerves which are rendered conspicuous by their surroundings.

Besides varieties of course and of distribution, the vessels upon the disk sometimes exhibit pulsation; and this, as it may be either a physiological phenomenon or an important symptom of disease, requires to be considered in this place. Under ordinary circumstances, the pulse-wave has died out before it reaches the central artery of the retina; and the blood both enters and leaves the eye in a smooth and unbroken current, the result of an accurate balance between the forces engaged in its propulsion and the re-

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[1] [To judge with perfect accuracy of the color of the different parts of the fundus, we should use daylight rather than any kind of lamplight. A hole in the window-shutter, covered with ground-glass or with thin white paper, affords a good source of light if the room is otherwise well darkened.]

sistance opposed to it by the tissues. Sometimes, however, this balance is disturbed, most usually, perhaps, by increase of resistance within the eye; and then a venous pulse, synchronous with the radial pulse, is the first result. The venous pulse has this character, that the larger veins lying on the disk are partially emptied during the acme of the pulse-wave; the blood contained in them being pushed back from the centre of the disk towards its margin, and returning from the margin to the centre during the intervals between the pulsations. The explanation seems to be that a certain portion of venous blood is displaced, and driven back towards the capillaries, in order to make room for the entering arterial current; but that, as the force of the pulse-wave subsides, the resistance of the veins to this return of their contained blood increases, until the preponderance is reversed, and the venous flow resumes its original direction. The venous pulse may be produced at pleasure, in almost any eye, by gentle but steady pressure with the tip of a finger, and this pressure may be conveniently made by the third finger of the hand which holds the object-lens. Pressure of a still higher degree produces an arterial pulse; and this differs from the venous pulse in the direction of its flow. The blood in the arteries recedes towards the heart; so that the arteries empty themselves from the margin of the disk towards its centre, and they refill, of course, in the opposite direction. The explanation is that the resistance to the entrance of blood is so great that it can only be overcome during the acme of the pulse-wave, when the *vis a tergo* is at its strongest. In healthy eyes, and with a natural state of the circulation, the pressure required to produce an arterial pulse is usually so great as temporarily to obscure vision by its interference with the blood-supply of the retina. It is manifest, however, that the balance of the intraocular circulation may be disturbed in two ways,—either by excess of resistance or by deficiency of propulsion; and that the excess of resistance may either be due to excess of contents within the eye, such as may be imitated for a time by digital pressure, or to increased tension of the arterioles themselves. As a matter of fact, I think the venous pulse is almost always due to increased intraocular tension, that is to say, to a state which either is or approaches glaucoma; and that the few eyes of young people in which a spontaneous venous pulse coexists with normal vision, are those in which physiological tension is carried nearly to its extreme limit, and in which the sclerotic is of a particularly firm and unyielding character. In persons beyond middle age, in whom a venous pulse either exists, or can be produced by very slight pressure, the eye is generally to be regarded as standing near the brink of glaucomatous change. An arterial pulse is seldom of this character; because the degree of glaucomatous tension required to produce it would in most cases produce also turbidity of the media, by which the pulse itself would be concealed, and by which, as well as by the pressure, vision would be seriously impaired. I have seen a spontaneous arterial pulse in several

persons suffering from heart disease—epecially in aortic regurgitation; and once, at least, in a case which seemed to admit of no other explanation than that there was an unusual tension of the arterial system generally. The patient was a boy of ten years old, complaining only of increasing dimness of sight, and whose optic disks presented the appearances of incipient atrophy. The nerve-tissue was pale, of a bluish tint rather than of its natural reddish-gray, and the sclerotic margin was conspicuous. There was a spontaneous pulse on both disks, and this was clearly shown by the erect image to be arterial. The tension of the globes was natural, and the boy was generally in good health. His heart was carefully examined by myself and others, and the examination revealed nothing abnormal. But the radial pulse, on both sides, was particularly small, hard, and wiry; and sphygmographic tracings, taken by Dr. Anstie, showed such curvatures as to confirm the impressions conveyed to the sense of touch. The case seemed to be one of general constriction of the arterial system; and the optic nerve and retina were certainly starved of blood, and were suffering in their nutrition accordingly. The patient has now been under my observation for about two years, and his retinal arteries no longer pulsate. The present blood-supply appears to be sufficient, and there seems no tendency to further atrophic change. But a certain degree of dimness of vision, which will probably be permanent, has been left behind; and the boy cannot read a smaller character than No. 4 Jäger's test-types.

[The whole explanation of the pulsation of the retinal vessels, and of its pathological significance, as given in the text, is so far at variance with that commonly accepted as to make it proper to state briefly the prevailing opinion.

"*Venous* pulsation is a physiological phenomenon which is scarcely ever absent, although not always easily detected. At the point where a retinal vein bends over to pass into the depths of the optic nerve, and especially if the vein bends suddenly so as to form a knuckle, as for instance in passing over the abrupt margin of a physiological excavation, a short portion of the vein is seen to collapse and become filled again in regular rhythm. The collapsing of the vein commences a little in advance of the radial pulse, beginning in the portion of the vein nearest the centre of the disk, and but seldom extending as far as its margin; it never extends beyond the disk into the region of the retina. The dilatation of the vein proceeds rapidly in a direction from the periphery towards the centre, and follows immediately the pulse at the wrist. Following the maximum of dilatation comes a short pause, after which the phenomenon of pulsation repeats itself.

"The phenomenon of venous pulsation is thus explained by Donders. The increased pressure under which the blood enters the arteries is in part propagated to the vitreous humor before it has time to reach the veins through the capillary circulation. Now, as the pressure of the blood within the veins becomes less

and less, the nearer they are to the heart, so the portion of the vein which offers the least resistance to the pressure of the vitreous humor upon it is exactly the main trunk just where it is about to pass out of the eyeball. This portion of the vein is therefore compressed, and its contents rapidly forced outward (*i.e., out of the eye*), while the uninterrupted current of blood from the capillaries is for the moment dammed up above the compressed portion. Following the heart's systole, and as soon as the distension of the arteries and the consequent pressure transmitted through the vitreous humor has passed off, the compression of the vein ceases, and the blood which had been dammed up in the peripheral portion of the vessel resumes its flow with increased swiftness. If the intraocular pressure is momentarily increased by slight pressure of the finger upon the globe, the venous pulsation becomes more conspicuous, or it may be thus evoked when it does not show itself spontaneously.

"In the *arteries* spontaneous pulsation occurs only under pathological conditions. It reveals itself by a jerking injection of the red blood-column into the arterial trunk at the time of the heart's systole, while during the heart's diastole the artery appears empty. The pulsation never extends beyond the limits of the optic disk, and can but seldom be followed even so far as the first branching of the main arterial trunk.

"Arterial pulsation occurs only when the pressure of the vitreous humor upon the walls of the vessel is greater than the pressure of the blood within the vessel, so that the blood can enter the artery only at the moment of sudden increase of pressure at the time of the heart's systole.

"A spontaneous arterial pulsation indicates a disturbed relation between the intraocular pressure and the pressure of the blood in the arteries.

"In the majority of cases it depends upon the abnormal increase of intraocular tension, which characterizes the disease glaucoma. It is rare that the opposite condition exists, viz., so great a diminution of the intra-arterial blood-pressure as to leave it too weak to balance a normal intraocular tension.

"This last condition may arise from mechanical obstruction to the circulation, such as intraorbital tumors or inflammatory swelling of the optic nerve, or it may depend upon weakening of the heart's action, as in an attack of faintness." Schweigger, *Handbuch der speciellen Augenheilkunde*, page 396.]

In this brief sketch of the methods of using the ophthalmoscope, and of the principles which should be applied to the interpretation of ophthalmoscopic appearances, I have aimed only at preparing the way for those descriptions of morbid changes which will form part of the accounts of the diseased conditions in which they severally occur.

CHAPTER IV.

THE PRINCIPLES OF OPHTHALMIC THERAPEUTICS.

If we disregard for the moment, and for the sake of argument, the rich store of merely empirical knowledge which has been bequeathed to us by former generations, or acquired in the course of our individual observation of the sick, I think it will be found that our power to deal successfully with eye disease, to arrest its course or to control its termination, is largely dependent upon the degree of accuracy with which we are able, in any case, to refer it to a local, a remote, or a constitutional origin, either singly or in combination, and to address our remedies to these origins, and to the results immediately springing from them, in such relative proportions as their respective importance may demand. Sir Thomas Watson, in his admirable *Lectures upon the Principles and Practice of Medicine*, mentions a detective policeman who suffered from ophthalmia as a consequence of exposure to cold by peeping for eight consecutive hours through a keyhole; and this case, I venture to think, may be accepted as a perfect illustration of disease of local origin. Examples almost equally satisfactory are furnished every day by the forms of conjunctivitis which follow the application of mechanical or chemical irritants or of contagious secretions; by ulcers of the cornea as results of injury; by the extension to the cornea of conjunctival inflammation; and by keratitis produced by the friction of granular lids. Among the maladies of constitutional origin, as far as we understand the phrase, the difficulty of selecting specimens arises only from their abundance and their variety. The iritis of an early stage of acquired syphilis, or the retino-choroiditis of a later period, the keratitis of inherited syphilis, the retinal changes in albuminuria, the retinal hæmorrhages of arterial degeneration, and the lenticular opacities of diabetes, are only a few of the types which first offer themselves to remembrance. In addition to these two great classes, I think we may recognize a third class also, in which the origin of the affection for which we are consulted is neither local nor constitutional, but only remote; in which some derangement of nervous function, possibly central, possibly occurring at a point intermediate between the centre and the periphery, determines a series of perversions of nutrition which eventually declare themselves by the production of physical changes, and constitute something which we call disease. I have come to regard many forms of variation of tension, or of inflammation of the iris or of the cornea, much in this way; that is, as expressions of a departure from the

normal innervation of the affected parts. They are, I think, essentially neuropathic in their character, differing from neuralgia chiefly in this respect,—that abnormal tissue change, instead of abnormal sensation, is the manner in which the malady declares itself.

Physiologists have long been acquainted with the influence exerted by the fifth nerve upon the nutrition of the eyeball, or at least with the fact that section of this nerve is frequently followed by ulceration and sloughing of the cornea. It is well known that Snellen entertained a belief that such ulceration and sloughing were not due to the loss of nerve influence, but only to the loss of the protection indirectly afforded by sensation, the animal no longer perceiving the presence and action of irritants, and no longer removing them by the closure of the eyelids or by friction. In support of this view, Snellen divided the fifth nerve in certain rabbits, and protected their eyes either by their own ears or by some other covering, with the result that their corneæ escaped while thus protected, and became ulcerated when the protection was taken away. It may doubtless be conceded that Snellen's hypothesis was to some extent correct, and that unfelt exposure to irritation may be one element in the causation of the ordinary result. Admitting this, his rabbits do not outweigh a great amount of clinical experience which is opposed to his conclusions; nor would they do so, even if it were always safe to argue at once from the rodentia to man. Cases of paralysis of the fifth nerve are frequently met with in practice, and loss of sensation is common to them all. In some, from first to last, there is no tendency to ulceration of the cornea. In others, this tendency appears only at a late period of the disease; often when sensation is partly re-established. In some it is present in a slight degree, and is obviated by the prompt use of a protective covering; while in others it is from the first uncontrollable, and leads to the speedy destruction of the eye. Exposure of the cornea to irritants, again, may be brought about by other causes, such as paralysis of the portio dura, which renders closure of the eyelids impossible, or by atrophy or deformity of the lids, so that they will no longer meet over the eye. I have seen examples of chronic facial paralysis, and also of ectropium, in which the lower lid had not been in contact with the eyeball for years, and in which there was thickening of the palpebral and ocular conjunctiva, and even some development of bloodvessels upon the surface of the cornea, but no trace of corneal ulceration. Among the occasional out-patients at St. George's Hospital there are two women who were long ago treated elsewhere for ingrowing eyelashes, and upon whom, with what seems to me to have been mistaken zeal, a method was pursued which was practiced by the Carthaginians in the case of Regulus. The women were not placed in barrels studded with spikes, but their eyelids were cut off with great freedom of hand. Their corneæ have shown no disposition to ulcerate, but the surface epithelium has become hypertrophied and opaque, and the eyes are dry and

skinlike. From such facts as these it would seem to follow that neither loss of sensation nor exposure, although probably predisposing to ulceration of the cornea, will produce it with any certainty, and that its occurrence must be dependent upon conditions connected with the nature, the seat, or the extent of the primary nerve lesion. Meissner, indeed, obtained some experimental results, which, so far as they are worth anything, are confirmatory of this view. He attempted to divide the fifth nerve in rabbits, and on three occasions so far succeeded that he abolished sensation in the parts supplied by it, but no inflammation or ulceration of the cornea followed. When the animals were killed, it was found that the division of the nerve had in all of them been incomplete, and that its internal portion had escaped without injury. Meissner next succeeded in dividing the internal portion alone, and he then obtained ulceration of the cornea without loss of sensation. Schiff, who repeated these experiments, has confirmed Meissner's results; while others who have followed him have been unable to do so. It seems to have been somewhat overlooked that Longet, more than a quarter of a century ago, believed himself to have established that division of the fifth nerve behind its ganglion was harmless to the nutrition of the eye, but that division anterior to the ganglion, which would cut off also many of the fibres of the sympathetic, was almost always followed by destructive inflammation. I have not been able to find any precise account of Longet's experiments; but we shall see hereafter that his conclusions are in very close accord with the results of clinical experience in the human subject.

Putting aside, however, as of very uncertain value, the evidence furnished by vivisections, which may implicate more or fewer structures than those aimed at by the experimenter, we have abundant proof of the remote origin of eye disease in the occurrence of what is called sympathetic ophthalmia. A wound of the eyeball, especially if it invades the ciliary region, or if, in the course of subsequent events, it produces tenderness of that region, is followed, in a great number of cases, by an inflammation of the uninjured eye, of a peculiarly obstinate and destructive character, which can have no other cause than the reflection of some morbid action from the nervous centres. This reflection may, indeed, be of two kinds; for in a few instances we see sympathetic irritation instead of sympathetic ophthalmia. Dr. Maats, writing on behalf of Professor Donders, has given a graphic description of a blacksmith in whom a destructive injury to one eye was followed by entire uselessness of the other, in consequence of intense photophobia, constant lacrymation, and spasm of the orbicularis. The man felt his way about with shaded eyes, bowed head, and spasmodically distorted features, and remained in this state for several months. He was placed under chloroform, and no disease of the eye could be discovered; but the remains of that which had been injured were removed, and he rose from the operating-table cured, and ready to resume his occupation as soon as he was permitted

to leave the hospital. Instances similar in kind, if slighter in degree, have been described by other authors, and it would seem that the occurrence of such irritation excludes the risk of the more formidable ophthalmia. But in the majority of cases, at no distant date after the ciliary region of one eye has been wounded, and even sometimes when the wound has been limited to other parts, we find in the other eye the commencement of an insidious form of plastic iritis, which usually resists all treatment, extends to the ciliary body and to the choroid, and terminates in wasting of the eyeball. Experience teaches that timely enucleation of the injured eye will prevent the occurrence of sympathetic ophthalmia; but it also teaches that enucleation, although not to be neglected, is of little use if once sympathetic ophthalmia has commenced. Professor Donders, by the careful dissection of injured eyes removed after the mischief has been done, has shown that an irritated ciliary nerve may generally be traced into the wound or cicatrix, and is therefore the probable channel of morbid action; and the fact that tenderness of the ciliary region of the injured eye is a symptom of the gravest import to the other seems to point also in the same direction. Of the three kinds of filaments which enter into the ciliary nerves, those from the motor root may probably be acquitted of all share in the mischief; but as between the sensory and the sympathetic fibres the question must remain in doubt. Mr. Vose Solomon accuses the optic nerve, but only on the ground that, in a single instance, sympathetic ophthalmia followed enucleation of the eye in a patient of his own, whose optic nerve, on account of some imperfection in the scissors employed, was bruised at the place of division, instead of being cleanly cut. The ciliary nerves immediately behind the eyeball surround the optic nerve so closely that they would be almost certain to participate in the bruising; and sympathetic ophthalmia certainly occurs after injury to parts with which the optic nerve has no anatomical connection. In one patient of my own, for example, it followed the extraction of cataract by Von Graefe's modified linear method; and Mr. Bowman, who saw the case, told me that it did not stand alone in his experience.[1] I have also seen sympathetic ophthalmia in a patient who had been operated upon by another surgeon for conical cornea. As far as I could ascertain, the summit of the cone had been removed somewhat freely, and the pupil had become partly adherent to the cicatrix. The course of the healing had not been prosperous, and the patient, disappointed at the progress of events, refused to submit to the iridectomy which was needed in order to restore a pupil, and which was still more needed on account of the adhesion. The eye operated upon became glaucomatous; and, when I saw it, sympathetic iritis of the other had commenced.

[1] [Over a dozen cases of sympathetic ophthalmia following cataract extraction by Von Graefe's method are mentioned, with more or less of detail, in the report of the meeting of the Ophthalmological Society at Heidelberg, for 1874.—*Klinische Monatsblätter für Augenheilkunde*, XII, pp. 334-344.]

The suggestion that an eye, even when damaged or useless, should be removed without delay, is often rejected by uneducated people; and hence sympathetic ophthalmia, which very rarely occurs in private practice, is scarcely ever absent from our hospitals. I believe, indeed, that many more cases are "sympathetic" than those in which the course of events can be clearly and unmistakably traced; but the latter are sufficiently numerous to establish, beyond the possibility of doubt, the position that a destructive form of inflammation of the eye is produced by a remote peripheral nervous irritation, reflected through the centres, and alike independent of constitutional taint or of local exciting causes.

The phenomena of true herpes allow us to carry the matter a step further. Physicians were long wont to give a conspicuous place among skin diseases to herpes zoster, or shingles, a pustular eruption which forms a demi-cincture round the trunk of the body, which maps out the cutaneous distribution of certain spinal nerves, and which is attended and followed by local pain of a severe character. Strangely enough, they overlooked, until quite recently, that a similar affection occurs with sufficient frequency in the cutaneous territory of the first division of the fifth nerve, that it is usually both more severe and more painful than herpes zoster of the body, and that it is liable to be followed, not only by very persistent neuralgia, but also by different forms of eye disease. Frontal, or trigeminal, or ophthalmic herpes, as it is now commonly called, was often confounded with facial erysipelas; and even within the last twelve months, notwithstanding all which has been written upon the subject, I have more than once seen this error committed. Mr. Hutchinson was, I believe, the first English writer who laid stress upon the true character of the disease; and both he and Mr. Bowman have since described and figured typical examples of it. The points in connection with its history which are important for my present purpose are that the original eruption is limited to the cutaneous structures, but that, after this cutaneous eruption has run its course, the eye of the same side is prone to suffer in two ways,—either by increase of tension, amounting sometimes to absolute glaucoma, or by ulceration of the cornea, which may run on to rapid perforation, and is often attended by iritis. These ophthalmic troubles may appear either singly or together, or sometimes in succession; and they may follow the cutaneous eruption either immediately, or after the lapse of days or weeks. They are frequently associated with intense and protracted frontal or circumorbital pain; and, even when not rapidly destructive, they are often beyond measure obstinate and intractable.

The nature of herpes zoster, and of the connection between the distribution of the eruption and that of the cutaneous nerves, was shown about the same time by cases recorded by Bärensprung and by Charcot. In Bärensprung's case, an outbreak of shingles, occurring, without known cause, in a tuberculous boy, extended from the sixth to the ninth rib. More than two inches in width,

it commenced posteriorly, not far from the middle line, between the sixth and the eighth vertebræ, and, forming a demi-cincture, it terminated exactly below the ensiform cartilage. The boy completely recovered from the shingles, which followed a regular course; but he died of phthisis six weeks after the first appearance of the eruption. The spinal ganglia of the sixth, seventh, and eighth nerves were found to be firmly adherent to the parietes of their intervertebral canals. The connective tissue in their neighborhood exhibited inflammatory redness, and the ganglia, as a whole, were increased in volume. The microscope showed that the neurilemma presented unquestionable traces of inflammation. There were, properly speaking, no discoverable changes in the nervous elements, either of the ganglia or of the nerves themselves. In Charcot's case the patient was a woman seventy-eight years of age, who died in the Salpêtrière. In this instance, again, the intervertebral ganglia and intercostal nerves, corresponding to the surface attacked by shingles, presented the same appearances as in that last described.

The publication of these cases led irresistibly to the inference that the cause of herpes frontalis must be an inflammation of the Gasserian ganglion, or of its coverings; and an opportunity of establishing the correctness of this inference on the post-mortem table was soon afterwards afforded. We know, therefore, that destructive inflammation of an eye may be excited by irritation of the ganglion on the sensory root of the fifth nerve; and the patients who suffer from frontal herpes are so numerous, and appear to have so little in common in other ways, that here again we may safely exclude the operation upon the eye itself of either constitutional or local causes.

In the cases in which palsy of the fifth nerve is attended by ophthalmic troubles, it is sometimes possible to determine the locality of the nerve lesion with great precision, and to place it still nearer to the eye than the ganglion. A man presented himself at St. George's Hospital, with a history of syphilis, with intense neuralgia of the first division of the fifth on the right side, together with anæsthesia of its cutaneous territory, and with absolute paralysis of all the motor nerves entering the orbit—of the third, the fourth, and the sixth. He had complete ptosis, dilated pupil, total loss of accommodation, and an eye motionless in a central position. With the aid of a lens, to supply the want of accommodation, he could read "brilliant" type, and he had neither dilatation of the veins of the retina nor general congestion of the eyeball. Such a combination of symptoms could hardly have been produced in any other way than by periosteal thickening at the sphenoidal fissure, pressing on the sensory nerve on the hither side of the ganglion. Under the use of ten-grain doses of iodide of potassium, given three times a day, the pain was soon relieved, and the motor power gradually returned; the internal rectus being the last muscle to resume its functional activity. But the cutaneous anæsthesia resisted treatment; and about a month after the patient was

first seen, the conjunctiva became injected, the eyeball hot, and the centre of the cornea turbid. At this time the power of the levator palpebræ was fully restored; and hence it may perhaps be said that the case furnished an instance of trouble arising from loss of the protection afforded by sensation. Careful observation, however, failed to afford evidence of any loss of protection, although the loss of sensation was complete. The lacrymal and mucous secretions were not deficient, and the ordinary involuntary movements of the eyelids took place in unison, on the right side as much as on the left. The hyperæmia and elevation of temperature seemed to point to fresh disablement of sympathetic filaments, rather than to an effect of the anæsthesia which had existed for some weeks before these symptoms declared themselves. The treatment consisted in the careful application of a compressive bandage, and in the administration of the iodide in larger doses, first of fifteen, then of twenty grains. The cornea never ulcerated, and the conjunctival redness slowly disappeared. But the anæsthesia, and the central turbidity of the cornea, which was sufficient practically to abolish vision, remained unaltered; and after six months the patient discontinued his attendance, and was lost sight of. The physical condition of the eye was such as to suggest the formation of an artificial pupil behind the transparent corneal margin; but I looked upon the case as one in which an operation of any kind would be highly dangerous, and would almost certainly be followed by sloughing of the cornea and destruction of the globe.

The influence exerted upon the eye by ordinary facial neuralgia is well known, and has of late been more carefully studied than at any former time. In nearly every instance of acute pain of the first division of the fifth, we find lacrymation and conjunctival hyperæmia of the affected side, and also increased tension of the globe, which, if the pain recur frequently, is apt to be established as a permanent condition. This fact was first brought into prominence by Wegner in the year 1866; and my own experience has assured me of the general accuracy of his observations. Nearly every case of glaucoma which I have seen in a comparatively young subject has had a history of antecedent neuralgia, not merely of ocular pain due to the increasing tension itself, but of paroxysmal pain in the whole region of the first division of the fifth; and nearly every patient who is subject to periodic facial neuralgia is conscious of, or will discover on observation, a marked clouding of vision on the affected side during the attack. I think, moreover, that the converse will hold good, and that, as a very general rule, anæsthesia of the fifth is associated with subnormal tension of the eyeball.

It is, therefore, not too much to affirm that we are familiar with grave changes of ocular nutrition, as ordinary results of remote nerve lesion, which may itself be situated either at the peripheral extremity of a nerve of the other eye, or on the ganglion of the nerve of the affected eye, or on the sensory trunk on the hither side of this ganglion, or at the unknown and presumably central

of paroxysmal neuralgia. There is nothing improbable in the ef that this kind of influence is exerted more frequently than hitherto been supposed; and clinical experience has long ago ed upon me the conviction that such is the case. I constantly eye disease, which cannot be referred to any known or definite al or constitutional cause, in which the pain or other nervous mptoms are in excess of the local lesions, and which resists the treatment that at first sight seems calculated to be successful. In such cases, especially when they occur in persons who have a neurotic family or individual history, or who have been subjected to severe emotional or intellectual strain, I am accustomed to assume the existence of some remote nervous change, and to bring this hypothesis to a therapeutical test. If I then succeed in curing the patient, I regard the truth of the hypothesis as being well-nigh proven. Take, for example, the various superficial corneal and conjunctival eruptions and ulcerations which were collectively described as "strumous ophthalmia" by old writers. We observe, in many of these cases, an element of extreme nervous irritation, manifested as photophobia, which varies greatly in degree in different patients, and even in the same patient at different times, and which stands in no apparent relation to the quantity or character of the local tissue changes. More important still, we find a certain number of these cases which resist all the methods of treatment that are commonly successful, but which yield almost immediately to the administration of arsenic—a medicine which acts upon many forms of neurosis with nearly as much certainty as quinine upon ague, and which almost establishes the general character and analogies of any malady that it cures. For an admirable sketch of the value of arsenic, especially from this point of view, I would refer to an introductory lecture by Dr. Clifford Allbutt, which was published in the *Lancet* in October, 1871.

Besides arsenic, the medicines which may be used to confirm a neurotic diagnosis in ophthalmic cases are mainly quinine, iron, bromide and iodide of potassium, and morphia. The influence of quinine and iron upon neuralgia forms part of the common stock of medical knowledge; but I think it is less widely known that these remedies are far more efficacious in combination than when given singly; that they are far more efficacious in small and frequently repeated doses than in larger ones separated by longer intervals, even though the same absolute amount may be taken; and that the certainty and celerity of their action may be much increased by the addition of a small quantity of morphia. I am indebted to my friend Mr. Gregory, of Stroud, for the knowledge that a pill containing a grain of quinine, two grains of potassio-tartrate of iron, and from a twelfth to a twenty-fourth of a grain of morphia, according to circumstances, and taken every hour until an expected paroxysm has been missed, will often cure periodic neuralgia with a rapidity and certainty not to be attained by any other method of administering the same medicines. I have found the same formula to be of the greatest possible value in

many cases of eye disease, in which local changes were progressing too rapidly to be overtaken by the use of a grain or two of quinine twice or thrice a day as a "tonic," but in which they were promptly arrested when the patient was brought under the influence of the specified combination.

The action of bromide of potassium upon the central nervous system, and probably upon the blood-supply of that system, is too well established, by its effect upon epilepsy and upon sleeplessness, to need any further remark than that some prescribers still give the salt in inefficient doses, taking ten grains as their average standard rather than twenty or thirty. But the iodide of potassium, on account of its great value in some of the later forms of syphilis, and on account of the large proportion of eye disease which may be traced to a syphilitic origin, holds a somewhat less assured position as an anti-neurotic. Many practitioners believe that the beneficial influence of the iodide, in any given case, almost establishes its syphilitic character; but in this opinion I am unable to concur. I think that iodide of potassium has a far wider range of usefulness than in syphilitic cases only; that like the bromide, it has a manifest influence upon the blood-supply of the brain, and that it cures maladies, such as recurrent nocturnal headache, which cannot be traced to a syphilitic origin, or described as syphilitic except by an abuse of language. Like the bromide, the iodide is frequently given in doses which are well-nigh useless; an error which perhaps arises from the circumstance that some patients are extremely susceptible to the action of the medicine. If we habitually order ten grains three times a day as a commencing dose, we shall find, in nearly all the cases in which the iodide is useful, that this dose may be rapidly increased to double or treble the quantity, or even beyond these limits. In some cases, doubtless, we shall find that the iodide does no good; and in a few we shall find that it is useful, but at the cost of coryza and other troublesome symptoms. I have to thank Mr. Hutchinson for the practical knowledge that, when the iodide is at the same time clearly indicated and badly borne, it is almost always possible, by reducing the dose, to obtain its advantages without attendant evils. The patients concerned are persons who are abnormally sensitive to the medicine, but they are abnormally sensitive alike to its remedial and to its poisonous action. For them, therefore, we may possibly find that two grains, or one grain, or even half a grain, will do as much as ten grains for the majority of people; and when we are told that a certain patient cannot take the iodide, or find by experience that he cannot take it in ten-grain doses without inconvenience, we should not on either ground abandon its administration, but should simply diminish the dose until we arrive at one which can be borne, and should then continue this until we see whether beneficial effects are likely to be produced by its employment. The principle of action is to begin with ten-grain doses, to increase them, by five grains or so at a time, if they are clearly useful, whenever there

is any arrest in the progress of improvement, and only to diminish them in the few instances in which coryza or other indications of iodism are produced. That a few people are abnormally sensitive to the action of a medicine is a circumstance which does not justify us in giving this medicine to the many in an inefficient manner. When iodide of potassium is really and urgently wanted, the administration of five grains twice a day, or of three grains three times a day, is little better than allowing the disease to run its course unchecked.

The larger doses, it must be remembered, require some circumspection with regard to the time and manner of their administration. They should generally be combined with four or five grains of carbonate of ammonia, and should be given in a large quantity of fluid. I am accustomed to direct the dose to be taken about an hour before a meal, and to be immediately preceded by half a tumblerful of barley water, which will insure the necessary dilution.

With regard to the use of morphia, or of other anodynes which may be better adapted to individual cases, it may be accepted as a sound general principle that no eye will get better while it is acutely painful; so that acute pain must always either subside or be subdued as a condition antecedent to recovery. Perhaps we might also say that a morbid state which is either originated or maintained by remote nervous irritation is not likely to improve in the absence of refreshing sleep. Premising that pain may be due to physical conditions—*e. g.*, to increased tension of the globe, to the pressure of a displaced lens upon the iris, to the protrusion of iris through a wound, or to the presence of a foreign body, and that in all such cases the necessary mechanical treatment must be first applied, and may prove to be all that is needed, we may say that the object of using anodynes is to subdue pain and to procure sleep; that for these purposes they must be given, if necessary, in repeated doses at regular intervals; and that they must be measured less by quantity than by their effects. It is seldom necessary or desirable to give anodynes for the moderate amount of pain which usually follows an operation, and which may be expected to subside in an hour or two; nor must we expect to render a diseased or injured eye free from sensations of discomfort. Such sensations are inseparable from abnormal conditions when the nerves themselves are healthy; and in feeble persons there is, for example, no less favorable symptom after a cataract operation than a total absence of pain or uneasiness. Such an absence usually points to a torpor of the nerves which is itself incompatible with speedy healing, and is a common precursor of an unsuccessful issue. But severe or long-continued pain indicates, and assists to maintain, a state of nervous irritation which is at least equally incompatible with repair, and which it is always necessary to subdue. Whenever acute or abiding pain is present in eye disease, we have a reason for the addition of anodynes to any other treatment which may be required; and this

addition should be made in an effectual manner, by giving to the patient or nurse the means of repeating the dose, if necessary, at stated intervals, until the desired effect has been obtained. It will not do to be content with administering a dose of morphia hypodermically in the evening, or with prescribing a pill to be taken at bedtime. Provision should be made for the continued administration, say of a quarter of the original quantity, hour by hour, until pain is subdued or sleep produced. There are certain forms of iritis in which the acuteness of pain is a prominent symptom; and it was chiefly in cases of this class that the late Mr. Zachariah Laurence succeeded, some years ago, in bringing about a cure by the use of large doses of opium or morphia alone. He kept his patients in a state of semi-narcotism for several days, or until all symptoms of acute inflammation had subsided. His original paper in the *Edinburgh Medical Journal* is still interesting; but it was written at a time when the importance of preventing adhesion of any part of the margin of the pupil was not sufficiently understood; and it is probable (the point not being mentioned) that many of his cases, although dismissed from treatment as cured, were left with synechiæ which could hardly fail to excite recurrent attacks of inflammation.

I have already mentioned in outline the distinctive characteristics of what may, perhaps, be called the neurotic forms of ophthalmia; but it may render these characteristics more definite if I relate the histories of one or two patients in whom they have been present.

Case I.—Some time in 1864 I was requested to visit Mr. M. I found a gentleman, about forty years of age, of robust muscular development, suffering from a sharp attack of iritis in the left eye. He had been for some days under the care of the practitioner by whom I was called in, and had been leeched to a small extent, but atropine had not been used. The patient was in bed, in a state of the most profound dejection, and in a room from which every ray of daylight was excluded, while his wife went about on tiptoe with a dimly burning candle. No history of either rheumatism or syphilis could be obtained. The patient suffered little or no pain, and had no physical intolerance of light; but was mentally afraid of its effect upon his eye, and its rigid exclusion was entirely his own act. His pulse was quick and weak, his skin relaxed, his appetite bad, his nights were sleepless. The iris had thrown out a good deal of lymph, the pupil was almost universally adherent, the aqueous humor was turbid, and vision was much impaired, but not more than the manifest changes in the anterior chamber would explain. The treatment had been the use of saline purgatives and diaphoretics, with low diet, and the application of a cooling lotion to the closed lids. Under the instillation of atropine, together with the internal use of quinine and ammonia, and the influence of a good diet and a favorable prognosis, things soon took a turn for the better. The pupil became dilated, the lymph and turbidity cleared away, and the

patient left his bedroom and resumed his ordinary manner of life. Some of the points of pupillary adhesion were very obstinate; but in course of time they all yielded to atropine, and the eye was restored to normal vision and to its original usefulness.

The subject of the foregoing history was a man of anxious temperament and scrupulous conscienticusness, the occupant of an arduous and responsible office under government. Shortly before his illness he had been directed to undertake a troublesome and delicate inquiry, which called for the investigation of numerous intricate accounts; and he had devoted himself to this duty for many days almost continuously, carrying on his work to a late hour of the night, and arriving at suspicions and conclusions which were very harassing to him. He had been distinctly overtasking a weak or sensitive nervous system, until the time when iritis cut short his labors. I did not at first perceive the full significance of the facts; but, by the light of subsequent events, I have come to regard his iritis as a phenomenon bearing much analogy to an attack of ordinary facial neuralgia, such as might easily have been excited under similar conditions.

Two years later this gentleman was removed, by promotion, to a different part of England, and his exertions in acquiring a knowledge of the details of duty in his new position were attended by a second attack of ophthalmia. He wrote to me in much anxiety. I prescribed atropine, abstinence from work, a good diet, and some increase in the quantity of his ordinary stimulus; telling him to come and see me if matters did not mend. His next report was that all was doing well; and although, from his description, I have little doubt about the matter, I cannot be sure that the iris was involved on this occasion.

In 1871 my patient was again promoted, and was placed in London, at the head of his branch of the service. Here he applied himself with great diligence, and under the pressure of a much increased responsibility, to master certain large and complicated matters. Before long he came to my house, with his right eye (not the one previously affected) hot, congested, and uncomfortable. The congestion was then purely conjunctival, the distended vessels could be emptied by pressure right up to the margin of the cornea, the sight was not in the least degree impaired, the aqueous humor was clear, the surface of the iris was lustrous, and the pupil was free and active. Knowing his previous history, I satisfied myself on all these points with extreme care; and, even when satisfied of them, advised the local application of atropine, together with a mild astringent, one grain of sulphate of zinc to an ounce of water. The pulse was without power, the general aspect dejected. I prescribed quinine with ammonia, and a chloral draught at night. For some days the state of the eye remained unchanged, and then a sudden and severe outburst of iritis occurred, with marked increase of tension, great congestion and swelling of the conjunctiva, and almost entire loss of vision, little more than a dim perception of light remaining. The pupil was

blocked up by lymph, and the whole aspect of the eye was excessively unpromising. As on the first attack, the patient perspired copiously, and his state of mental distress was pitiable. There was not a trace of rheumatism, either in his symptoms or in his family history; and when I again inquired about syphilis, he assured me that he had never contracted it, and that his youth and early manhood had been spent in a remote part of the Highlands of Scotland, where in those days the disease was actually unknown. In severe iritis of the ordinary type I am accustomed to place my chief reliance upon mercury; but here there seemed to be no indication for it, and no reason to expect benefit from its use. I tapped the anterior chamber, and evacuated the aqueous humor twice daily, so as to reduce tension, and applied a four-grain solution of atropine. For two or three days matters mended slightly, and then the atropine produced violent erysipelatous inflammation of the eyelids and cheek, the upper lid becoming so swollen and brawny that the cornea could scarcely be seen. The atropine was, of course, laid aside, compresses wrung out of iced water were applied to the cheek and eyelid during the day, and a lead ointment and water-dressing during the night. Matters slowly improved, until, in the course of a few days, I was induced, by persistent sleeplessness, to lay aside other medicines in favor of twenty-five grain doses of bromide of potassium, given three times a day. From that date improvement was rapid, and the eye soon regained its natural aspect. A cautious use of atropine showed that the lower half of the pupillary margin was adherent to the anterior capsule; but the adhesion was not in the way of vision, and now, four years having elapsed, it has never been a source of trouble. In this case I venture to think that we have essentially the history of a neurosis, whether we test it by the apparent exciting cause, by the vaso-motor paralysis evidenced by the unusual amount of congestion, by the paroxysmal character of the last attack of iritis, or by the treatment from which the greatest benefit was derived.

CASE II.—I was called early one morning to see a medical practitioner, on account of discomfort in his right eye. When a student, he had contracted a chancre on one of his hands in attending a labor. Not at first suspecting the character of the sore, he suffered severely from constitutional syphilis; and, at the time of which I speak, many years later, was still occasionally liable to tertiary eruptions. His eyes had never been in any way implicated. He had, when I saw him, been greatly overworked both physically and mentally, and was suffering anxiety from domestic causes. On examining the eye, I found extreme contraction of the pupil, with corresponding spasm of the accommodation; so that distant vision was obscured, but the smallest type was easily read near at hand. The iris was quite lustrous; there was no congestion, and the only complaint was of a tight, uneasy, tensive sensation in the eyeball. I applied a four-grain solution of atropine, and waited an hour to see the effect; but scarcely any dilatation of the pupil

was produced. In the course of the day iritis set in with great severity. I need not dwell on the details of the case, which terminated in complete recovery. Its interest, from my present point of view, turns upon the precursory spasm of the ciliary muscle and of the sphincter pupillæ, spasm which seemed to point to some remote source of irritation in the nervous system, either central or reflected from the periphery, as the exciting cause of the inflammation.

CASE III.—A male patient in one of the medical wards of St. George's Hospital, who was convalescent from subacute rheumatism, was referred to me because his right eye was congested, and the light gave him pain. Photophobia depends, generally speaking, upon the ciliary region being abnormally sensitive to movement; so that pain is produced by the changes by which the diameter of the pupil is adjusted for variations of light. It means tenderness of the ciliary region, either from inflammation or from hyperæsthesia. In this case there was no evidence of inflammation, and there was certainly no iritis. The flushing of the conjunctiva was due, I thought, to weakness of the vaso-motor nerves. Bromide of potassium was prescribed, the symptoms were speedily relieved, and my functions in relation to the patient terminated. A few days later I was asked to see him again, on account of impairment of the sight of the same eye. I then found no pain, and very little redness, but the pupillary margin was tied down, at two or three points, by the adhesions of an insidious iritis.

In the last two cases, it may perhaps be objected to my idea of a neurosis that there was in each a dyscrasia—in the one rheumatism, in the other syphilis—with which iritis is commonly associated, and that we need not look beyond these for the causes of its occurrence. My reply is, first, that iritis is not an ordinary attendant either of a late period of syphilis or of convalescence after rheumatism; secondly, that the manner of invasion was in each case indicative of nervous irritation or derangement as an early link in the chain of events; and, thirdly, that we are by no means sure that a transmitted nerve influence may not be among the channels through which a dyscrasia may produce its effects upon the structures of the eye.

CASE IV.—Miss —— was brought to me by her usual medical attendant. She was a single lady, forty years of age, of emotional temperament, and working hard in a very arduous profession. In early life she had been subject to migraine, and of late years to facial neuralgia, which was liable to be brought on by any unusual fatigue or annoyance. She was plump and well nourished, with a soft and delicate skin, and a dark complexion. Her hair, once black, had become quite gray before she was thirty, but was long and very abundant. She was still menstruating regularly and in natural quantity, but always suffered from languor, and generally from neuralgia, during the periods. She was an only child; her father had been dead for some years, and she could give no information about his last illness; her mother was living, but hemiplegic.

Her right eye was natural in appearance, but its sight had been very defective from early childhood, and it was of little use to her, although the ophthalmoscope showed nothing to account for the amblyopia. The left eye, for which she consulted me, had been painful, and losing vision rapidly, for three or four days, and, at the time of her visit, was practically blind. She could see the position of the window in front of her, but could not count fingers. The eye presented a perfect type of acute glaucoma. The conjunctiva was injected, but not sufficiently to conceal the distended veins which passed out through the sclerotic. The cornea had a misty aspect, like that of a glass which had been breathed upon; the pupil was semi-dilated, the iris was pressed forwards towards the cornea, and the tension of the globe was extremely high. Iridectomy was performed the same day; and when the bandages were removed after the operation it was manifest that great improvement of sight had taken place. But the vessels of the iris, as well as those of the sclerotic and conjunctiva, had bled freely; and a comparatively large amount of blood had been left in the anterior chamber, and was only slowly absorbed. The operation wound healed kindly, the tension was reduced, and the cornea was clear and bright; but the conjunctiva, both ocular and palpebral, remained much congested, and the plica semilunaris was swollen into quite a prominent fold. The patient could read the largest of Jäger's types; but at this point she remained almost stationary, sometimes improving a little and sometimes falling back, for nearly six weeks. During this time she took, by turns, bromide of potassium, quinine with ammonia, and phosphorus with nux vomica, together with occasional sedatives. A compressive bandage, generally moistened with some anodyne lotion, was applied to the closed eyelids, and the plica and the palpebral conjunctiva were carefully pencilled, on two or three occasions, with solid diluted nitrate of silver, which seemed to do neither good nor harm. The patient was fed as well as her appetite would allow, and was directed to take drives in the open air. Things were in this state, when one day a turbid white patch appeared on the cornea, below its centre, and rapidly developed into an ulcer, which increased so fast, both in extent and in depth, that it threatened to perforate in a few days. I formed the worst possible opinion of the case, and, rather because I knew not what else to do than for any better reason, determined to try the effect of iodide of potassium. Ten-grain doses, given three times a day, arrested the progress of the ulcer within twenty-four hours, but occasioned coryza and an unpleasant taste in the mouth. The dose was reduced to seven grains, and rapid and complete recovery was produced. Within a fortnight the ulcer had healed, and the conjunctival redness had almost disappeared. The patient went to the country, and then to the seaside, but continued the iodide for several weeks, with the result that the cicatrix of the ulcer can only be discovered by careful examination. She has become presbyopic, and requires spectacles for reading; but, with this exception, her sight is as good as ever

it was, and she is now actively engaged in her professional duties. The effect of the iodide of potassium was as marked and as unmistakable as it often is in the syphilitic forms of paralysis: but the idea of syphilis seems to me to be untenable. Putting aside the good repute and the unmarried state of the patient, I should regard her general physical condition as being itself almost conclusive upon the point. I should attribute alike the high tension, the congestion, and the corneal ulceration, to some influence transmitted through the fifth nerve, and in which its sympathetic filaments were largely concerned.

CASE V.—A widow lady, seventy years of age, was sent to me by her medical attendant. She had iritis of the left eye, and a marginal ulcer on the inner side of the cornea, extending about a third of the way round, and with two points of deeper ulceration, containing sloughs, in its course. The centre of the cornea was clear, the pupil was adherent by several points to the anterior capsule, but was not much contracted, and vision was reduced to one-third. The conjunctiva was congested, and there was no pain. The treatment had been quinine, fomentations, and good diet, but no atropine. I advised a four-grain solution of atropine to be used three times a day, a compressive bandage to be alternated with hot fomentations, and bromide of potassium internally. If no great improvement took place in three days the bromide was to be replaced by the iodide. I did not see the patient again, but learned that after three days the iodide had been given as suggested, with immediate and great benefit. Six weeks afterwards I heard that the eye was "quite well." I cannot understand why a vigorous old lady of seventy should have inflammation at once of the iris and of the cornea of one eye only, without any manifest predisposing or exciting cause, unless from some influence exerted through the nerves which govern the nutrition of the parts concerned.

If we pass on now to consider the affections which are of constitutional origin, we are necessarily confronted in the first place by syphilis, the most far-reaching and the most widely diffused morbid poison of which we have any knowledge. We shall scarcely see a single case of eye disease, as distinguished from defects of shape or of function, in which we shall not have to weigh the question, "Is this syphilitic?" and the number of instances will be very large in which the balance of probability will incline to an affirmative reply. If we include all its known forms, syphilis attacks [nearly] every important structure of the eye directly—the cornea, the iris, the retina, the choroid, and the vitreous being all the common seats of distinctly syphilitic affections. It also, and in many different ways, attacks the eye indirectly, as when syphilitic paralysis of the third nerve produces ptosis, or when syphilitic paralysis of the fourth or sixth produces double vision, or when syphilitic paralysis of the fifth nerve produces (as we have seen) corneal opacity or ulceration, or when syphilitic tumors in the brain produce the changes which have been described by

authors as optic neuritis, with the attendant liability to consecutive atrophy and blindness. The question of the diagnosis of syphilis is one upon which it is not necessary here to dwell, further than to say that, from various social and domestic reasons, and on account of certain obvious temptations to untruthfulness, it is often beset by great difficulties; while at the same time, it may be absolutely necessary for the surgeon to arrive at some definite conclusion with regard to it. The occurrence of iritis in one eye of a previously healthy young woman, soon after her marriage to a man who is likely to have contracted syphilis, but who denies having done so, is perhaps as good an example as can be found of the practical bearing of an oftentimes insoluble problem. In such a case it is generally a simple matter to cure the iritis, whatever may be its nature; and supposing it not to be syphilitic there will then be an end of the difficulty. But if it should be syphilitic, the patient, when her iritis is cured, will only have completed the first link in a long chain of morbid action, likely to entail suffering and perhaps premature death upon herself, and to be continued to the next generation of her children. From such a fate she may be rescued if the surgeon can say that the affection of the eye is an expression of a constitutional malady, and can induce her to submit to the treatment necessary for its cure. When certainty is not attainable, high probability must be accepted as a guide, and it is better to be content with high probability than to enter upon inquiries which may be productive of domestic unhappiness; always remembering, however, that the patient should have the benefit of a doubt in this sense,—that to overlook actual syphilis is, in practice, perhaps the most serious of all errors, while to suspect its presence when it is not there, and to act upon the suspicion discreetly, are errors indeed, but errors which may relatively be described as trivial. The nature of the case renders it incumbent upon every practitioner to cultivate, in the highest possible degree, the faculty of recognizing the external signs of syphilis, so that he may be able to form a diagnosis independently of history. It is not sufficient to know that syphilitic eruptions usually leave copper-colored stains; but all the effects of the disease should be studied with the care which was bestowed upon symptoms by the physicians of an earlier day, before the multiplication of instruments of diagnosis had produced our own comparative independence of the art of personal observation. Whoever, in dealing with declared syphilis, leaves nothing unnoticed, will often come upon the track of the undeclared as an Indian recovers a trail in the wilderness, by signs which cannot mislead, but which are too slight to engage the attention of less cultivated faculties.

The worst manifestations of ocular syphilis which have fallen under my own notice have occurred in patients in whom the primary disease had been recognized, but who had been lulled into a false security after an inadequate period of treatment, which had indeed removed local symptoms, but had left the constitutional

malady untouched. A few years ago, more than at present, it was the custom for surgeons to begin the management of syphilis well, and to stop prematurely in the midst of their well-doing. A man contracted a chancre, and his inguinal glands became indurated. He was treated with mercury for perhaps six weeks, or until the chancre had healed and some trivial secondary eruption had appeared and faded, and then he was allowed to lay aside the medicine. He was told that he might or might not have further secondary symptoms; and that, if they appeared, it would be sufficient to treat them with iodide of potassium. The great debt of gratitude which the world owes to Ricord has been materially enhanced by his long life, which has enabled him to witness the end of things, to watch over his patients from their adolescence to their old age; and to see, in many cases, the manhood of two generations of their descendants. From the evidence gathered during an experience which is nearly as unparalleled in its duration as in its extent, he tells us that syphilis is radically and permanently curable, but that it cannot be cured, as a rule, otherwise than by a course of mercury, continued, with due intermissions and precautions, for something like twelve months. Less than this will, indeed, in most cases, leave the patient apparently well, but the disease will be likely again to declare itself at some future time, and often in some of the obscure forms, the nature of which we have only recently learned to recognize.

In 1857, a young gentleman, reading in London for his army examination, contracted a venereal sore, and wrote to me for advice about it. I was then living in the country, and I told him to go to an eminent hospital surgeon, and to pay implicit obedience to his directions. The sore was pronounced to be a hard chancre, and mercury was given in the way to which I have referred. After a few weeks it was discontinued, and patient and doctor were both satisfied. The former obtained his commission, and went to India with his regiment. He was a keen sportsman, and after snipe-shooting in some marshes was attacked by what was called rheumatism, and was sent to England. Here he recovered, and went to Aldershot on duty; but was again attacked, and was sent away from the camp to his father's house, where he had been lying in bed for a month when I was asked to see him. Many of his joints were swollen and tender, and he was quite helpless. I told his medical attendant of the chancre, and we agreed to lay aside all other treatment in favor of iodide of potassium. In a week our patient was riding about on horseback, and he soon returned to duty. A year or two later his syphilis showed itself again, this time by occlusion of a cerebral artery and consequent hemiplegia; so that this gentleman, not then twenty-five years of age, was crippled and disabled for life. Such a history is common enough; but any individual practitioner usually sees only part of it, and the part which chiefly falls under my observation is the cropping up of syphilitic disease of the retina or choroid, or the growth of brain tumors producing secondary mischief in the eye. A few

months ago, for example, a gentleman came to me with loss of central vision in one eye; and the ophthalmoscope showed a patch of disease over the region of the macula lutea. I expressed my belief that this patch was syphilitic, and inquired his history. Three years previously he had contracted a chancre, and had been treated for it in Ireland, by an eminent surgeon now deceased. At my request he wrote to the druggist who had compounded his medicine, and obtained copies of the prescriptions, with the dates at which they were prepared and repeated. It appeared that he had been under mercurial inunction for a fortnight, and that afterwards he had taken small doses of the perchloride for four weeks, making six weeks of mercury in all; and this was the result. Analogous cases present themselves every day to those who will take the trouble of tracing out a chain of antecedents.

The instances in which we are led by iritis to the discovery of an early stage of syphilis present no difficulty with regard to treatment, except such as may arise from the indocility or the circumstances of the patient. We have but to cure the iritis in the ordinary way, and apply to the syphilis the principles which Ricord has so clearly stated. If the patient will not take mercury for the necessary time, so much the worse for him; and, if he is forewarned of the probable consequences, the surgeon is relieved of all responsibility. That the mercury should be cautiously given, and in such a way as to avoid the production of its poisonous effects, is a matter of common sense on which it is unnecessary here to dwell.

When the period of primary syphilis has long passed away, and when mercury has been given for a few weeks, as in the cases above cited, it is much more difficult to decide upon the course to be pursued. We have then two remedies between which to choose, mercury and iodide of potassium. Of these, iodide of potassium is the more rapid in its influence upon the symptoms actually present, but it probably possesses little or no power to cure the systemic malady. Nothing in clinical history is more remarkable than the rapid amelioration of the symptoms of late forms of syphilis under the use of the iodide; nothing is more certain, generally speaking, than their recurrence in the same or in some modified form. Mercury, on the other hand, will be slower in producing its first action, but more effectual as against the syphilitic taint; although it is not proven that syphilis of long standing can be cured by mercury, at least with anything like the same certainty as the earlier stages of the disease. It is in the eye, however, that the immediately curative effects of mercury are most remarkable; and it is from its visible action upon iritic effusions that many inferences have been drawn with regard to its supposed kindred action in parts of the body which are concealed from view—as, for instance, in the pleura. I am indebted to my lamented friend, the late Dr. Anstie, for the suggestion that these inferences may possibly be in some degree erroneous. He believed mercury to have some special elective affinity for, or special action upon, the parts which are sup-

ied by the fifth nerve, and he did not admit that its manifest fluence upon iritis is necessarily an evidence that it will exert a nilar or equal influence elsewhere. In support of this view it ay be said that the poisonous effect of mercury is displayed first pon the gums, which derive their nerve-supply from the source dicated; and we may also find something analogous in the eposition of lead in the gums, coupled with its tendency to pro-uce atrophy of the optic nerves. The suggestion is one upon hich I need not dwell, but it will serve to call to mind the power-effect of mercury upon the eye, as well as the possibility that argument from the eye to other organs may be fallacious. urning to the question immediately under consideration—the ce between mercury and iodide of potassium—it may perhaps aid that the best rule of practice is to inquire whether the local ges in actual progress are such as to inflict irreparable injury s they are speedily arrested. If they are, iodide of potassium should be given in the first instance, and should be continued until a distinct impression is made upon the case; when it may be laid aside, and mercury given instead of it, with the hope of anticipating subsequent phases of mischief. If the changes in progress are not of this pressing character, it may often be best to give mercury from the first. A corneal ulcer threatening to spread or to perforate, so that in two or three days it might permanently impair the eye as an organ of vision, or an amount of effusion in the nerve-disk likely to lead to speedy atrophy by its interference with the local circulation, would either of them call for the most rapid influence which the iodide could afford. A mere haziness of the cornea, or a turbidity of the vitreous body, or a limited amount of retinal or choroidal change, may be taken to illustrate conditions in which it would be legitimate to wait for the more gradual operation of mercury.

The mode of administering iodide of potassium has been already described; and concerning the administration of mercury there is nothing to be said which has any special application to the eye. The skill of modern pharmaceutists has multiplied preparations; but by these I have not been tempted to forsake old and trusted friends. Sir Astley Cooper was wont to tell his pupils that if they were much addicted to new remedies two results would inevitably follow: first, they would not cure their patients; secondly, they would have no patients to cure. For the most part I am accustomed to gain a knowledge of the new remedies chiefly by reading or hearing the accounts given of them by others; and I feel that the weapons I have long employed are those which, in my own hands at least, are most likely to do good service. In order to obtain mercurial influence quickly I use either blue pill, or inunction with blue ointment, or both together; and, for prolonged administration, the perchloride. Inunction is often useful for adults, but its especial value is in the case of young infants suffering from a combination of purulent ophthalmia with inherited syph-

ilis. For them, the plan I prefer is to smear every day a little fresh ointment on a slip of flannel about an inch and a half wide, which is buttoned round the abdomen, next the skin, and worn constantly. Mr. Hutchinson is accustomed to have the ointment rubbed into the soles of the feet, the only part of an infant's skin on which it never produces irritation. To this there are no other objections than the trouble of protecting the hands of the rubber, and the ill consequences which may follow if the protection should be incomplete. Together with the pill or the inunction, except in the case of infants, it is often necessary to employ a little opium to prevent griping or purgation: the perchloride combines admirably with iron, or quinine, or arsenic, or with any two of them, and is generally more effective in combination than alone. To this armamentarium I am beginning to add a preparation which is of sufficiently good repute to deserve an extended trial, namely, Staub's chloro-albuminate for hypodermic injection; but I cannot yet speak of it from an experience large enough to form the foundation of an opinion. Calomel, with precautions and under conditions which will be described when discussing the diseases of the cornea, is often useful as a local application; but, given internally, it has no advantage over blue pill, and the calomel vapor baths so much extolled by my esteemed colleague, Mr. Henry Lee, have appeared to me to be somewhat uncertain in their operation, and, sometimes, to be too energetic. For these reasons they do not always fulfil what I regard as essential to a good method of mercurial treatment, namely, that the surgeon should hold the reins of it in his hand. We are much indebted to Mr. Haynes Walton for the force and clearness with which he has pointed out the boundary between the remedial and the poisonous action of mercury; and this boundary the prescriber should never transgress. Save in the exceptional cases of idiosyncrasy, in which mercurial poisoning may be produced by a single moderate dose, there should be no such thing as a sore mouth resulting from treatment. The slightest line upon the gums indicates a point beyond which the medicine should not be pushed; and the highest art of administering mercury is to keep the patient, as it were, on the brink of this line, without permitting transgression of it. For this purpose, the inexperienced practitioner must be content to feel his way; and the most experienced will constantly find that he can do little more.

The other forms of constitutional malady which entail proclivities to eye disease are chiefly gout, rheumatism, albuminuria, and diabetes; and there is little to be said concerning them beyond the obvious caution that they must not be overlooked, and that the general treatment which any of them, when present, would require, must be combined with the local treatment which the affection of the eye may render necessary. Again, there are certain temporary states of system which would materially affect both the prognosis and the treatment of ocular disorders apparently identical in their nature. A hæmorrhage in an eccentric portion of the retina, occur-

ring in a woman whose whole circulation is deranged at the period of cessation of the menstrual function, calls for little more than the ordinary precautions of the time; while a similar hæmorrhage in a man of the same age would suggest extensive disorder of the arterial system, and would, in all probability, be the precursor of renal disease or of apoplexy. Hence it is always necessary to inquire, in any case of eye disease, not only with regard to the presence or absence of what may be called the greater forms of dyscrasia, but also, generally, "What is there lying behind this local change?" The inquiry becomes especially important in the case of patients who are passing from middle life towards old age, but there is no period at which it can be neglected with impunity. Appetite, diet, exercise, sleep, the tone of mind, the nature and amount of work, the character of the atmosphere habitually breathed, and the balance between waste, repair, and supply, as shown by the state of the excretions, should all be systematically inquired into. A patient cannot make a speedy and satisfactory recovery if he is underfed or overfed, if he leads an unduly sedentary life in vitiated air, if his brain is overworked or harassed by emotions or anxiety, if his sleep is insufficient, or if his system is loaded with waste which his excreting organs fail to remove. Neglect of these conditions is not an uncommon result of too early a devotion to specialism on the part of the practitioner; and, in its effect upon the patient, is a fruitful parent of chronicity and of relapse.

It must not be inferred from the foregoing observations that the local treatment of eye-disease is to be neglected, or that it is unworthy of the closest and most careful attention. On the contrary, whatever may be the background, so to speak, of remote or of constitutional causation, and however necessary it may be that this background should be modified by circumstances or removed by art, yet still, in all the maladies of the parts anterior to the crystalline lens—that is, of the iris, the cornea, or the conjunctiva—the character of the local treatment will usually determine the degree of excellence of the local recovery. An eye is liable to be spoiled for visual purposes by even a brief continuance of certain morbid processes; and it is, therefore, the business of the surgeon to terminate these processes as rapidly as possible. Their gravity may be due solely to their situation; and, just as a degree of inflammation which would be trivial in any other part of the mucous membrane may destroy life when it occurs in the larynx, so an ulceration, which would elsewhere be left to run its course, may destroy vision when it occurs upon the cornea. If a patient has a syphilitic ulcer of the leg, we need take little trouble about local applications, because we know that healing will occur under the influence of rest and of antisyphilitic internal medication. But if he has a syphilitic ulcer of the cornea, we must remember that the difference between judicious and injudicious local treatment may determine whether this ulcer will extend or deepen for two or three days longer than it need, whether it will

perforate, and whether it will leave a mere nebula or a cicatrix disfiguring to the appearance and disturbing to the sight. In vascular inflammation of the cornea it may depend, in great measure, upon local treatment, whether the curvature of the membrane will undergo injurious modification. In iritis, it may depend upon local treatment whether the pupillary margin will be left adherent to the lens. Lastly, in many of the more acute forms of conjunctivitis, it may depend upon local treatment whether the cornea will escape injury, and whether the malady will be cured in a reasonable time, or will lapse into a state of absolutely indefinite duration and of infinite possibilities of mischief. While, therefore, we must neither overlook nor neglect to treat the systemic conditions on which affections of the eye may more or less depend, we must not place reliance upon constitutional treatment alone, to the neglect of the various local applications by which the local malady can be conducted to a safe and speedy termination. Of the two errors, the less serious would be to neglect the constitutional treatment, because this neglect may often be repaired on some future occasion: while, on the other hand, a corneal ulcer suffered unduly to extend itself, or an iritis suffered to establish firm adhesions, may easily produce consequences which will be altogether irreparable.

There are certain principles of local treatment, of very general applicability, which it will save repetition to state once for all in this preliminary chapter. In the healthy eye, the lids are constantly passing to and fro over its surface, so as to remove particles of dirt deposited from the atmosphere and to diffuse the tears and conjunctival mucus evenly over the globe. In diseased conditions, when the conjunctiva and cornea are roughened by the projection of distended bloodvessels, and when the natural secretions are altered or diminished, and especially when there is any abrasion or loss of the corneal surface, the friction of the lids becomes not only painful but injurious, and their movements are at the same time increased in energy and frequency by reflected irritation. It then becomes necessary that they should be restrained; and for this purpose we employ what is known as a "compressive bandage." This is composed of a small piece of fine linen to cover the lids, some carded cotton-wool for padding, and a roller, about an inch and a half wide and nearly two yards long, formed of any fine elastic material, but preferably either of what is called "water-dressing bandage" or of flannel gauze. The free end of the roller should be placed on the forehead over the affected eye, and the first turn should be made across the forehead and round the head horizontally, so as to secure the end. When the roller reaches the forehead, over the sound eye, for the second time, it should be inclined downwards, carried under the lobe of the ear, round the occiput, under the lobe of the second ear, and then upwards across the face, over the affected eye, to the forehead. Before the roller is brought over the affected eye, the small piece of linen should be placed upon the closed lids, and all the hollows of the orbit

should be filled and padded with the cotton-wool, in sufficient quantity to allow the roller to exert distinct but gentle and uniform pressure on the parts beneath. When the roller reaches the forehead, it should be secured to the horizontal turn by a pin, and then a second horizontal turn over all will complete the application. By varying the quantity of wool and the degree of tightness of the roller, any desired amount of pressure may be exerted by this bandage, which, if properly applied, is very little liable to be displaced. Too much care cannot be taken in filling the orbital hollows and in so distributing the wool that its pressure may be uniform; because, if a bunch of wool were simply applied to the lids over the convexity of the globe, and then bound tightly on, the effects of such a proceeding would often be disastrous. For a patient who is able to walk out, and who objects to the white bandage as being unsightly, a tolerably efficient substitute may be made by a double piece of soft black silk, six inches long, and an inch and a half broad, neatly hemmed, turned in to a point at each end, and having three-quarters of a yard of narrow soft black ribbon sewn to each point. The silk may be placed obliquely over the carded wool, with one point coming to the temple on the sound side, the other under the lobe of the ear on the affected side. The ribbons may then be brought to meet at the occiput, crossed there, brought horizontally round the head, and tied in front, or over the ear.

There are many circumstances under which it is desirable to apply cold or heat to the eye; the former to moderate, the latter (as in the case of sloughing ulcers of the cornea) to promote vascular action. For these purposes we employ compresses of various kinds. For cold, the compresses should be of fine linen, about two inches long by an inch and a half broad, smoothly and evenly folded, and composed of from four to six thicknesses of material. Half a dozen or so being prepared, they should be steeped in a basin of cold water, in which, if necessary, a lump of ice may be floating, and which should be placed close to the patient. The nurse takes out the first compress, squeezes it in her fingers just sufficiently to prevent water trickling from it when it is applied, and places it gently over the closed lids. In a time varying from one to five minutes, according to the heat of the part and the effect desired, the compress should be exchanged for a second, the first being replaced in the water [or on the ice]. The object of having several in use at once is that by taking them in regular rotation each may have time to become cold before it is reapplied. If the water is hard, and the skin of the eyelids delicate, it is well to apply a little olive or almond oil to the latter, to prevent superficial irritation.

For the application of heat the flat compress is less effectual than something lighter and more bulky; and for this purpose small sponges may be employed, wrung out of hot water in a similar manner. Von Graefe was accustomed to use hot chamomile fomentations, and to apply them by means of little muslin bags, in

which a few chamomile flowers were sewn up prior to being boiled. Each bag, as it was taken from the eye, was returned to the decoction to recover its temperature; and it is obvious that, whether water or some medicated liquid is employed, it must be kept hot during the whole period of application, either by a spirit-lamp or some similar contrivance, or by additions of fresh hot liquid from time to time. As a rule, neither heat nor cold should be applied to the eyes continuously for any long period; and an hour, twice or thrice a day, will usually be enough for either. In the intervals the compressive bandage should be carefully adjusted.

[In the severer forms of acute ophthalmia, and especially in the very severe and dangerous form dependent upon gonorrhœal inoculation, it is generally thought essential to keep up the use of iced compresses, without intermission, sometimes for days together.]

The bandage, by excluding light and by preventing movement, affords a considerable degree of rest to the eye, and thus places it under conditions favorable to recovery. But in order to obtain complete physiological rest it is necessary to have recourse also to atropine, which paralyzes for a time both the sphincter of the pupil and the ciliary muscle, and thus establishes absolute internal relaxation and passivity of the organ. Furthermore, on account of the close functional union and sympathy which exists between the eyes, it is necessary, whenever one is seriously affected to enforce entire rest of its fellow—that is to say, to enjoin abstinence from reading, writing, or any other pursuit requiring visual application, as well as avoidance of exposure to dust, cold winds, heat, or glare.

The use of atropine for the purpose above mentioned is best accomplished by a solution in distilled water of the neutral sulphate, of a strength of from two to four grains to the ounce. This solution, when the drug is pure and neutral, is absolutely unirritating to most eyes; and a drop may be placed in the lower conjunctival fold, near the outer canthus, two or three times a day. For the purpose of making the application there is nothing better than a goose-quill, cut to a blunt scoop;[1] but considering the highly poisonous nature of the liquid, it is perhaps safest to send it out in special bottles, with a dropping apparatus attached. Various contrivances have been devised for this purpose; but the best of them is a little blown-glass bottle of the size and shape shown in Fig. 36. By slightly warming the bulb of this bottle in the flame of a spirit-lamp, the contained air is caused to expand: and then, by inverting the bottle, and dipping its beak into the solution, a sufficient quantity will be driven through the capillary opening by atmospheric pressure. In use, it is only necessary to invert the bottle, holding it in the

FIG. 36.

[1] [Excellent dropping-tubes of glass, provided with a small rubber cap, are now everywhere procurable.]

warm hand, and to touch the lining of the lower eyelid with its beak, from which a drop will issue.

If the application of atropine should be painful, the most probable explanation is that the drug is impure or not neutral, or that sulphuric acid has been either set free by spontaneous changes or added by the dispenser to obtain a clear solution. In such case, no time should be lost in obtaining a fresh supply. But when atropine has been long in use, the best preparation is apt to cause local irritation in some persons, and this irritation is usually more manifest in the eyelids. and especially on the lower lid, and on the adjacent skin of the cheek, than elsewhere. It may be readily recognized by a peculiar stiffness and dryness of the inflamed skin; and the swelling of the eyelid is usually sufficient to remove the lower lacrymal punctum from contact with the globe, and thus to produce an overflow of tears. Under such circumstances, the atropine must be laid aside, and some soothing application made to the closed lids. The best is, I think, the compound ointment of subacetate of lead of the British Pharmacopœia, which may be applied to the skin freely, and a soft bread-and-water poultice laid over it. But it is a rule without exception that no preparation of lead should enter an eye when there is any loss of corneal epithelium; because we are then liable to have an opaque deposit of carbonate of lead formed upon the surface. If the corneal surface should be ulcerated or abraded, it is the safest practice not to let lead come into use, even as an external application, for fear of mischance; and in such cases I prescribe for the atropine irritation a simple ointment, into which a little sedative solution of opium has been stirred—perhaps in the proportion of half a fluid drachm to an ounce of ointment. There are some persons, however, by whom no preparation of atropine or of belladonna can be borne even for a time; all of them alike producing an erysipelatous inflammation. Such instances are rare; but there are few writers on ophthalmic surgery who do not record one or more from personal experience, and I have myself met with two of them. It is unnecessary to say that such an idiosyncrasy places a most formidable obstacle in the way of treating iritis and various other affections.

In the case of children, and especially the children of the poor, who are often roughly handled by their parents, and who have not learnt to trust to them, the proper application of atropine is sometimes a matter of considerable difficulty; and the solution is apt to be washed out, or at least diluted, by tears. At hospitals we constantly see children for whom atropine has been prescribed, but whose pupils are not dilated. Occasionally, perhaps, no one at home has taken any trouble about the matter; but more frequently, I believe, the drops have gone over the cheeks, or anywhere but into the eyes, or they have been applied in such a way as to produce plentiful crying. In hospital practice these children can be brought every day, so that the application may be made effectually; and it will often be desirable to use, instead of the

, the little wafers of atropinized gelatin which were de- Mr. Streatfeild. I do not like these wafers for common ause they produce more smarting than the solution; but ing children they have a great advantage in the fact that ssolve slowly, so that the medicament is not liable to be away by a gush of tears.

ractice of depletion, which was formerly largely followed halmic surgeons, is now confined within narrow limits. It carcely credible, but is none the less a fact, that it was once ry to bleed copiously from the arm in iritis and in purulent mia, and even to follow the bleeding by the application of ss leeches. It is a curious matter of history that the various for making a leech take more than once had their origin normous demand for these creatures which was occasioned epidemic of contagious ophthalmia that prevailed in Berlin ear 1820. At the present day we take blood in eye diseases aringly, and chiefly by two methods,—the natural and the l leech. The natural leech is very useful in many super- iseases; the artificial leech chiefly in those of the deeper the eyeball. In any form of ophthalmia which is attended eat heat and swelling of the eyelids, in some cases of iritis, ome cases of injury, including many operations for cataract, may often be usefully applied. The best position is usually e frontal bone, immediately external to the margin of the nd a little above the level of the external canthus. I say rather than leeches, because I think it undesirable to mul- tes. When more blood is required than one leech would be o draw, the best plan is to make a free longitudinal incision, sharp lancet, into the creature when it is nearly full, and hen continue sucking until it is detached, being no longer nienced by the distension of its alimentary canal and integ- The incision should be made in the side of the leech, near dal extremity. The artificial leech is much more rapid in n than the natural one; and is essentially a cupping instru- dapted to take a few ounces of blood quickly from the al region. The form in common use is that of Heurteloup, ed by some recent modifications. The cutting portion con- a sharp punch, capable of being set to any desired depth, de to revolve rapidly by releasing a coiled spring. The received in a glass cylinder which is pressed upon the skin the wound, and which has a well-fitted piston, worked by rod. As the operator screws up the piston, the blood fol- fill the vacuum which is produced. The knack of appli- consists chiefly in not turning the screw too quickly; for ise, if the piston be drawn up faster than the blood can flow, n of the operation will be considerable. Whenever this of depletion is used for deepseated maladies, such as those etina or choroid, it is desirable to keep the patient in almost rkness for the next twenty-four hours, so as to avoid a

vascular reaction by which the original congestion might be increased.

The remaining forms of local treatment consist almost entirely of applications which are special to particular maladies, and will be described when these maladies are themselves brought under consideration.

CHAPTER V.

THE PRINCIPLES OF OPHTHALMIC SURGERY.

THE eye and its appendages, notwithstanding the delicacy and complexity of the structures of which they are composed, or perhaps even by reason of this delicacy and complexity, are extremely tolerant of discreet surgical interference, and are made the subjects of a great variety of operations. Some of these have for their object the removal of an opaque substance from the visual track; others, the displacement of the pupil from behind an opacity which does not admit of removal; others, the liberation of the iris from restraint, or the establishment of a free pupillary opening; others, the diminution of injurious intraocular tension. The foregoing aim at the preservation, the improvement, or the restoration of sight, and may be regarded as the capital operations of ophthalmic surgery; while a secondary group is formed by those which are chiefly designed to improve the appearance of the patient, such as the operation for squint,[1] or for staining and concealing a conspicuous corneal cicatrix. A third group, which may be illustrated by operations for malposition of the eyelids, holds a somewhat intermediate position, and its members may be productive of both visual and cosmetic improvement; while there will still remain a few procedures which are only called for under exceptional conditions, or for which it would be difficult to find an appropriate classification. It is manifest that an account of the details of any particular operation will be most appropriately given in connection with an account of the conditions which the operation is intended to relieve; but there are certain considerations which are applicable to ophthalmic operations generally, and which it seems possible to bring together, to the saving both of time and space, within the limits of a preliminary chapter.

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[1] [The operation for squint has often a higher purpose than mere cosmetic effect, viz., the restoration of binocular vision.]

The operative surgery of the eye is an art which demands, from any who would either understand or practice it, a careful and twofold study: first, a study of the mechanical acts that are to be accomplished, and of the difficulties that may interfere with their accomplishment; next, the training of the hands to the uses to which they are to be put. Such study, moreover, should not be considered superfluous by any surgical practitioner, however little he may design to be an ophthalmic specialist; for, as there are conditions in which the prompt performance of iridectomy is at least as essential to the preservation of vision as the prompt performance of herniotomy, or the prompt deligation of an artery, can ever be to the preservation of life, so no one should think himself entirely fitted to enter upon the responsibilities of surgical practice until he has prepared himself for the discharge of either duty in an efficient and creditable manner.

The means by which the objects of the ophthalmic surgeon are accomplished are the instruments which are employed and the hands which employ them. Surgical mechanicians have provided us with instruments in almost infinite variety; but the hands take precedence of them all, and deserve our earliest and most careful consideration. It was said, first, I believe, by Beer, and has been repeated by many since his day, that an ophthalmic operator must spoil a hatful of eyes before he cures one. As the instruments of any period are a fixed quantity, and as adequate knowledge concerning when and why to operate may be obtained by attentively observing the practice of others, it is manifest that the hatful of eyes must be a sacrifice offered up to the training of the hands. If we regard Beer's saying as even a gross exaggeration, repeated chiefly for its vivacity and its force, we cannot thus explain away the familiar maxim of political economy that all learners spoil a portion of raw material. This maxim expresses one of the verities of life; and a surgeon who learns to operate by using the eyes of human beings to begin with, and by thus in time gaining manual dexterity at haphazard—gaining by sheer practice the power to do things well which he at first did badly,—although he may eventually become skilful, obtains his skilfulness at an unwarrantable cost. Instead of seeking such dearly bought experience, it is better first to consider carefully the nature of the mechanical acts which are to be undertaken, and then to see how far, and by what means, the hands can be trained to the possession of the qualities required from them. There is a contrivance, with a name in shopkeepers' Greek, by which persons learning to play on musical instruments may acquire strength and flexibility of finger without the production of sounds distressing to those in their vicinity; and on the same principle the hands of most persons may be so far educated, before a human eye is touched by them, as to render the accidents which may result from awkwardness unlikely, if not impossible. I say of most persons, because there are some to whom the nature of their organization denies the attainment of any kind of mechanical

skill. Those cannot become ambidextrous who have been born ambisinistrous; and a want of power readily to estimate nice differences in the degree and the direction of exerted force seems to be, occasionally at least, the result of some structural peculiarity in the muscular or nervous system. It is perhaps peculiarity rather than defect, for it constitutes a characteristic of certain races, and also, I think, one of the most marked organic differences between the sexes. It is a curious fact that the industry of silk-throwing, which is profitably pursued in many northern counties, has died out in, and has been driven away from, the west of England, on account of the excess of waste produced by the want of manual, or rather of digital, cleverness on the part of the children. The children of the operative classes in the west seemed not to be endowed with fingers and thumbs to be used in piecing broken threads, and to have no idea of any lesser grasp than a handful, gained by shutting the fingers collectively against the palm. The Hebrews, again, obviously as a result of the traditions by which their national life has been controlled, are conspicuously inferior to Gentile races in mechanical dexterity;[1] and I have been told of a Jewish ophthalmologist, the subtlety of whose brain-work is unsurpassed, that he "operates from the shoulder." No one who carefully watches the muscular acts of women will fail to perceive a tendency to do them with a sort of jerk or rush, with a superabundance and a sudden exertion of force, rather than by the gradual putting forth of the precise amount by which the end in view can be secured. The same tendency may be observed less frequently in men; and those by whom it is displayed, if they have sufficiently mistaken their vocation to become surgeons, would do well to recognize their weakness, so far at least as to turn their energies into some other channel than the performance of delicate operations upon the human subject.

The qualities of hand which are combined in an accomplished eye-operator may be summed up under the following heads, each of which will demand a brief separate consideration:

1. A high development of what is called by physiologists "muscular sense"—the faculty by which we feel and estimate the degree of force we are exerting, either in pressure or traction.

2. The power of uniting the two hands in consentaneous movement, and of directing the intelligence to them simultaneously; so that they may work smoothly and harmoniously together as a single organ for the attainment of a common object, and may both at once be equally under the control and governance of the will.

3. The power to employ the left hand, indifferently with the right, for the guidance and use of cutting or other instruments.

4. Steadiness.

[1] [The distinguished ability displayed by many Jews as performers upon musical instruments would seem to tell against the author's generalization as regards that race; nor do women seem to be at all wanting in the capacity for being trained to perform work requiring delicate and accurate use of the hands.]

It is by means of muscular sense that we are able to combine the precise degree of force which will accomplish our end with the utmost gentleness in its application. There is a period in cataract extraction in which the operator may require important help from an assistant, and in which the value of a cultivated muscular sense is often exhibited in a striking manner. It is when an incision has been made into the anterior chamber, the aqueous humor has been evacuated, and the eyeball, rolled upwards by the reflex action of the superior rectus, must be drawn somewhat down before iridectomy can be performed. For this purpose a pair of forceps should be made to close almost imperceptibly upon the conjunctiva and its subjacent tissue, and traction should be applied so gently that the eye will roll quietly down as soon as the muscular resistance is overcome. There will then be no strain upon its coats, and no gaping of the wound, unless the action of the superior rectus should be spasmodic, in which case a more profound anæsthesia would be indicated. But if the assistant snatches the conjunctiva hastily, and drags upon it rudely, it may well happen that the wound will gape, the zonule of Zinn be ruptured, and the vitreous humor prolapse. The necessary gentleness does not imply slowness; but it implies that the first exercise of force shall be less than the amount required, and that the deficiency shall be made up by gradually increasing effort. The same principle applies not only to all forms of forceps traction, but also to all incisions in the eye, which, while they are primarily punctures, should never be plunges or stabs. In making them we should place the point of the knife or needle upon the spot to be penetrated, with a pressure which increases in proportion to the resistance, but so gently that the speed of movement of the instrument is not accelerated when the resistance is overcome. In the aged, and in eyes which have been long diseased, we often find the cornea soft, thin, and flaccid; and if we were to apply to such eyes a knife or needle, with the full pressure which would be necessary in order to penetrate a healthy cornea, we should incur risk of driving the point of the instrument further than it was intended to go, while the shock or concussion to the eyeball would tend to expel the aqueous humor, which it is often most important to retain. Not only in the actual steps of an operation, but in all preliminary proceedings, in the estimation of tension, in raising or lowering an eyelid, or in testing the steadiness of the globe and the sensitiveness of the ocular surface, the touch of the finger should be as gentle as the fall of a snowflake, while this gentleness should cover a reserve of force sufficient for any proceeding which circumstances may demand.

The consentaneous movement of both hands is demanded by the frequent use of two instruments at once within the eye, and still more by the practice, now become almost universal, of fixing the eye by forceps or other contrivances. The fixation instrument may be used either to steady the globe in some required position,

or to move it somewhat against the edge of the cutting instrument; and in either case it should exert no undesigned pressure, and should never be forgotten by the consciousness. An unpracticed operator, when using a knife or needle in one hand, is very liable unconsciously to make pressure with the forceps in the other, and in this way may do mischief which a proper governance of the comparatively passive hand would have avoided.

The requirement of ambidexterity arises from the circumstance that it is generally most convenient for the operator to stand behind the head of the recumbent patient, while, at the same time, the projection of the nose renders it necessary that nearly all incisions should be commenced from the temporal side. A few not otherwise unskilful oculists have failed in attaining ambidexterity; and some of these have displayed sufficient human nature to contemn in others the accomplishment which was denied to themselves, or which they had not taken sufficient pains to acquire. By methods more or less awkward, by coming round in front of the patient for the left eye, and by committing fixation to an assistant, it is doubtless possible to do most ophthalmic operations with the right hand alone. I have heard of one surgeon who places his patient upon a chair, and then seats himself upon the patient's knees, in order to get at the left eye with the right hand. His contrivance is undeniably ingenious, but the ingenuity is perhaps somewhat perverted. No one who has paid adequate attention to the subject can entertain a doubt that the ordinary incapacity of the left hand does not depend upon any great organic difference between the two, but that it is chiefly a result of the customs of society, in compliance with which children are chidden and restrained whenever they attempt to do with the left hand anything which is ordinarily done with the right. In the collected works of Benjamin Franklin there is an interesting paper on this subject, written in a quaint serio-comic vein, and entitled *The Complaint of a Neglected Half-Brother.* Franklin makes the left hand declare that it had an equal birthright with its fellow, but that all its powers have been repressed and rendered useless by adverse circumstances. Not only has it never been taught a trade, but it has never been permitted to apply itself even to the humblest forms of industry. It is not so generally known as it might be that the difficulty of a first attempt at writing with the left hand depends almost entirely on the direction of the movement from left to right, and on the customary slope of the letters. It is comparatively easy to write with the left hand the reverse way—that is, to execute with the left hand a movement analogous to that which we constantly execute with the right. Any person who is temporarily deprived of the right hand may conduct correspondence with the left by writing with a style the reverse way, on thin paper with carbonic paper underneath. The sheet must then be turned over to be read, and the words will run in the ordinary fashion. Sufficient ambidexterity for the use of the knife in the left hand will follow, as a matter of course, from the training necessary to afford

complete mastery of fixation instruments; and full surgical ambidexterity may usually be attained with a very moderate degree of practice and trouble.

[In discussing the importance of ambidexterity to the surgeon the real question is whether it is, on the whole, better to train the left hand chiefly as an aid and helper to the right hand, or to attempt to make it do all kinds of work interchangeably with the right hand. Surgeons of the highest eminence, and of unquestioned ability as operators, differ as to how far it is profitable to train the left hand to take the leading part in certain operative manipulations, and there can be little question that different operators will continue to hold different views upon this subject. The obvious rule for each surgeon would seem to be to operate in the way in which he finds that he can operate best, and this is for many surgeons to let the right hand always take the leading part and to train the left hand, mainly or exclusively, to aid and second the right hand. A high degree of ambidexterity is certainly an elegant accomplishment, but the power to acquire it varies with different persons, and inability to reverse the usual relation of the right and left hand to each other is not among the weightier disqualifications for even the most delicate branch of operative surgery.]

For good operating absolute steadiness is indispensable, because the commencement or the course of an incision should not deviate by the fraction of a line from the previously formed plan of the surgeon, and because it is often necessary to introduce a blunt instrument, such as a hook or closed forceps, through a small opening previously made for the purpose. In order to avoid, in such cases, premature loss of aqueous humor, as well as to avoid any bruising of neighboring parts, the blunt instrument should be placed at once between the lips of the puncture prepared for its reception. Steadiness, as a mere physical attainment, is one of the results of training; but there is an unsteadiness produced by mental causes, by anxiety to do right, or by want of self-reliance, which may amount to a positive disqualification for operating, and which, in its minor degrees, is best met by avoiding the more delicate procedures until time has been given for the gradual growth of confidence, and for the gradual influence of success.

In order to train the hands to the acquirement of the qualities above described, there is a great deal that may be done by simple means, in the many broken periods of leisure which so constantly offer themselves and are so constantly thrown away. In speaking of the ophthalmoscope, I have tried to point out that the mastery of any complicated mechanical procedure should be obtained piecemeal; the eventual combination of different movements being far more easy than their simultaneous acquisition. On this principle the first thing to be done, as a preliminary to operations upon the eye, is the practice of equal and consentaneous movements of the hands. Free drawing with both at once is perhaps the best exercise for this purpose. The paper should be placed on a desk, conveniently sloping so as to support the ulnar margins of the hands

just in front of the wrists, and then two similar curves should be drawn simultaneously by the fingers only, so as to meet in, or to proceed from the same point. Two pencils should at first be used, and it will be found that several difficulties have to be overcome. The left hand will lag behind the right, and will move with less freedom, so as to form a smaller curve, and to form it more slowly. When the power of simultaneous and similar movement has been gained, there will still be differences in the amount of pressure exerted; and these differences may be rendered visible by substituting fine pens for pencils, so that the degree of pressure will determine the thickness of the line. To such exercises many short intervals of time may be profitably devoted, with the result that before long the two hands will be combined by the volition and intelligence into one machine, made up, indeed, of essentially independent parts, but still capable of combined and harmonious action. There will yet be much room for cultivating the frequently neglected muscles of the left hand, and for accustoming them to execute combined and delicate movements. In the way of mere gymnastic training, a good exercise is to slip a moderately strong elastic ring over the conjoined tips of the fingers and thumb, and then to separate and approximate them by turns. For combined muscular action, drawing, or fingering a musical instrument with the left hand, will both be useful, and by such means it will soon become easy to perform with it any manipulation which it can ever be required to accomplish.

When the hands have become accustomed to work together, and to work with equal speed, delicacy, and force, there is a simple mechanical contrivance, shown in Fig. 37, which may be used yet further to facilitate the acquirement of dexterity. It is a mask representing the human face, and set upon a jointed pedestal capable of being fixed at any angle, so as to render the plane of the face vertical, horizontal, or inclined. Behind holes corresponding to the orbital openings there are spring clips, constructed to hold artificial eyes, or the eyes of animals, and fixed to spiral springs, so that the inserted eyes obtain somewhat of the natural mobility. By the aid of this mask it is possible to imitate very closely the physical conditions under which operations are actually performed. At first the orbital hollows may be left vacant, in order to practice holding the knives and needles required. An instrument in a handle should be held like a pen between the thumb and first two fingers, while the remaining fingers and a portion of the ulnar margin of the hand rest upon the brow; and the position should be such that the

FIG. 37.

fulcrum need never be shifted, and that all necessary movements may be performed by the simple flexion or extension of the grasping fingers. In this way the operator should be able to touch every part of the margin of the orbital opening; and to execute any thrusting or cutting movement within its limits. Next, the orbital hollows may be filled with something to represent eyes. Small wooden balls, covered with white leather, on which a circle is drawn to represent the corneal margin, are very convenient to begin with. The leather covering may be seized by fixation forceps, and the operator may proceed to mark the corneal margin by minute dots placed at close and regular intervals. If he use a fine pen, he will produce a permanent record of his power to place the point of an instrument precisely upon a selected spot; and he may next proceed to connect any two dots by a line. The eyes of recently killed animals may then be inserted, and upon them all the steps of the principal operations may be performed. The best eyes are those of pigs, cats and rabbits; the two latter being especially well adapted for operations upon the iris. The animals should be killed by some method which does not produce extreme dilatation of the pupil, otherwise there will be hardly any iris to seize. In pigs and sheep the iris is of a structure which scarcely at all represents that of the human eye; but the cornea, allowance being made for its greater thickness, is sufficiently well adapted for the requirements of practice.

The first impression produced by the foregoing paragraphs will probably be that I advise all who wish to operate upon the eye to take a great deal of preliminary trouble. Such is precisely my recommendation. It has been well said that what the vulgar call genius is little more than a capacity for taking trouble; and in this particular matter I am sure that the trouble will be well repaid. A surgeon who obtains a junior appointment to an ophthalmic hospital, for example, will some day be called upon to operate for the first time—perhaps suddenly, in an emergency, such as acute glaucoma, perhaps under the ken of critical observers, before whom he will be especially desirous to acquit himself well. If he has trained his hands, not necessarily in the precise way that I have suggested, but in accordance with the principles underlying my suggestions, he will find himself familiar with the nature of the task he is called upon to undertake, and will approach it as a skilful craftsman, and not, as might otherwise befall, as an awkward and blundering novice. I believe it is impossible to acquire manual dexterity merely by watching others; partly for the reason that the facile working of a finished operator conceals from spectators the difficulty of that which he accomplishes. His skill is like the simplicity of perfect English composition, which, as Dugald Stewart long ago said, induces the reader to think that he also could write in a similar manner. It has more than once been my lot to see attempts to operate upon the human eye made by a surgeon who did not even know how to hold the instruments he was about to misuse; and I can conceive few things more painful than such a

spectacle, except the reflections that would afterwards be suggested to him by the inevitable consequences of his so-called operation.

I proceed now to the consideration of instruments, of which, as I have said, there exists an almost bewildering variety. Charrière, of Paris, has formed a museum of forgotten eye instruments, with which to demonstrate to ingenious persons the truth of Solomon's dictum, that there is nothing new under the sun. I should be afraid to say how many specimens this museum contains. But the instruments now living, so to speak, and familiar to us, may be divided into two great classes: the essential, which are the representatives of inventive ingenuity, and the superfluous, which are the representatives of inventive awkwardness. The former class have been contrived by good mechanicians, the latter by bad surgeons. There are certain things for which the fingers cannot be spared, or which they cannot do, and for these things instruments are essential. The fingers cannot be spared to hold open the eyelids; and therefore, as the fingers of an assistant would be in the way, specula are essential. The fingers cannot fix the eyeball without exerting dangerous pressure, and therefore fixation instruments are essential. The utility of iris forceps, of hooks, of scissors, of cutting blades of different sizes and shapes, requires no demonstration; and each of these must be adapted to the work it is intended to perform. But in all ages and countries the bad workman has complained of his tools, and the good workman has produced the most varied results by the most simple means. A man who is very awkward, and whose awkwardness is perpetually bringing him to grief, hits upon a contrivance by which he hopes that this natural result may in some degree be obviated. He calls his contrivance an invention; and, like those persons of whom it is said that their glory is in their shame, he is often somewhat proud of it. Many surgeons of great and deserved repute have invented each a single instrument, such as Beer's knife or Tyrrel's hook; and some have invented more than one, chiefly because they have struck out some new procedure for which new appliances were indispensable. But, as a rule, the invention of many instruments by a surgeon may be accepted as a sufficient proof of his clumsiness; and when, without valid reason, any single operator has his peculiar scissors, and his peculiar hook, and his peculiar forceps, and his peculiar scoop, all called after his name, it is more than probable that the gift of fingers has not been bestowed upon him. The safest man is he who never invented an instrument in his life, but whose daily practice affords evidence that he can use those which have been invented for him by others.

The instruments which come first under consideration are the so-called specula, for separating and fixing the eyelids. The conditions to be fulfilled by them are that they should be self-retaining and not liable to slip; capable of being adjusted to any desired width of opening, and stiff enough, when fixed, to resist the action of a strong orbicularis; that they should exert no pressure upon the globe, should be readily inserted and removed, and never in the way of the operator. I know only one form in which these

desiderata are combined; and that, which is shown in Fig. 38, was designed by Mr. Foveaux, of the firm of Weiss and Son. It opens to any width that its cross-bar will permit, and can be fixed at any point by the screw stop. The cross-bar is too near the eye, and the limbs of the speculum are too stout, for the latter to be

FIG. 38.

bent or closed by muscular effort, and the curve removes the bar quite out of the way of the handles of the instruments. The speculum is reversible, and may be used for either eye; but it is well to have two sizes, one for young children, the other for older children and adults. It must be introduced gently, when nearly closed, and with the bar on the temporal side, and its limbs must then be separated to the required extent, so as to put the lids fully upon the stretch, and fixed by a turn of the screw. It should not open of itself by a spring at the joint, but should be opened by putting two fingers between the limbs and separating them; for it will be found in practice that a speculum with a strong spring will occasionally slip from the fingers of the surgeon during introduction or removal, and may then strike a smart blow upon the eye.[1] When properly adjusted, the curved parts under the lids should be too far asunder to press upon the globe themselves, or to allow the lids to do so, and the general direction of the instrument should be horizontal, neither inclined downwards towards the cheek, nor upwards towards the temple. A great many modifications of this form may be found in shops; but they are all, I think, modifications for the worse. Grooved plates to receive and contain the eyelids, pins to run across over the eyelids, elaborate cross-bars between the limbs, and studs to limit the extent of opening or closing, are all very pretty to look at, but are of no practical advantage, and are to be condemned as unnecessary departures from simplicity. There is a different form, the invention of Dr. Noyes, of New York, which is sometimes useful. As shown in Fig. 39, it consists of two short limbs working by rack and pinion on a curved aluminium bar. This bar is always placed next the nose, so that the speculum is not reversible, and a separate one is required for each eye. The advantage of Noyes's speculum is that it leaves the temporal side quite open and free; and this is convenient

FIG. 39.

[1] [This objection does not apply to specula made with a weak spring, and they are certainly much more conveniently handled.]

for some purposes, especially for division of the external rectus muscle, or for introducing instruments into the vitreous chamber. But its bar on the nasal side somewhat interferes with fixation, and diminishes the usefulness of the contrivance for operations in general.

When the speculum is properly adjusted, the eyeball itself is unrestrained, and is freely movable in all directions; but as a preliminary to delicate and carefully planned incisions, it must be steadied and held fast. For this purpose, many meritorious instruments have been invented; but those most useful are three in number, the double hook, the conjunctival fixing forceps, and the sclerotic fixing forceps. The double hook, shown of natural size in Fig. 40, is an old instrument lately revived. It is held between the forefinger and thumb, and placed lightly upon the conjunctiva near the corneal margin, with its shaft and handle in the direction of a line drawn through the point of impact to the centre of the eyeball. The handle is then made to rotate, so that the points bury themselves in the conjunctiva, and, turning in opposite directions, twist the tissues into a little rope. The conjunctiva, thus twisted, is scarcely at all liable to tear; and, as the hooks do not let go until they are released by rotation in a contrary direction, the instrument may be left in position between the different steps of an operation, and may be passed from hand to hand. The operator may fix the eye himself for his first incision, may give the hook to an assistant during a subsequent procedure, and may eventually resume it, without having to take a second hold, and therefore with only one conjunctival wound. When done with, a movement of backward rotation liberates the points instantly. The conjunctival fixing forceps have a flat blunt extremity when closed, and one blade has two little teeth, which are received between three corresponding teeth of the other. Fig. 41 shows the entire instrument, and, at A, B, and C, the points, both open and closed, of natural size. In use, the instrument is directed to the centre of the eyeball, and is gently pressed upon the conjunctiva, near the corneal margin, with the blades separated to the extent of one or two lines or more, according to the degree of laxity of the membrane. The blades are then closed, in such a manner that they pinch up not only a fold of conjunctiva, but also the subconjunctival connective tissue; and the extremity of the closed forceps must be kept in gentle contact with the globe while the requisite traction is being applied. This instrument holds well in young and healthy eyes, if it is used in the manner described; but, in the aged, and after prolonged inflammation, the conjunctival tissues often tear with great readiness, and then the forceps are not only liable to produce troublesome lacerations, but also to lose command of the eyeball at some critical period of an opera-

FIG. 40.

tion. The same accidents happen much more readily with blades that are too fine at their extremities, or that have only one and two points instead of two and three; and they will happen with any instruments, or in any eyes, if too small a fold of conjunctiva is pinched up, and if this fold is lifted off the sclerotic. The surgeon is therefore to some extent dependent upon an assistant for the proper application of the instrument, and it is judicious, before commencing an operation, to see that the assistant thoroughly understands this part of his duty. An operator who is ambidextrous will only require an assistant to fix when he is himself using two instruments of other kinds;[1] but some who are not ambidextrous commit fixation to another even in their primary incisions upon the left eye. This course should always, if possible, be avoided; for, however expert the assistant, there can never be the same consent between the hands of different people as between the hands of the same person, and the harmony between the fixing and the cutting hand should be absolute. While the one presses the sharp instrument into the eye, the other should lift or rotate the eye towards the instrument. It is said that when two surgeons are associated in lithotomy the one who is the more skilful should hold the staff, and in like manner, if fixation and incision are to be divided, the post of honor should be to undertake the former duty. The sclerotic, or perforating fixing forceps, obviate all risk of tearing the conjunctiva. They were contrived about the same time by Mr. Bader, of Guy's Hospital, and by M. David, of Angers. Each blade terminates in a single fine sharp point, and the two points cross to the extent of a line, as shown in Fig. 42. In use, the forceps are closed until the points are about a line apart. These points are placed on the sclerotic, immediately external to the corneal margin, and are directed towards the centre of the eyeball. They are then driven in and closed by a simultaneous movement, and

FIG. 41.

FIG. 42.

1 [An operator not ambidextrous will ordinarily fix the eye with his left hand while making the incision with the right hand. By ambidexterity we understand the power of using the two hands interchangeably.]

they hold the eye with a grasp which never gives way. They seldom perforate the anterior chamber; but their doing so would be unimportant, as they fill their own punctures until they are removed. I have never seen these punctures become the seat of irritation, or give any subsequent trouble, and I have employed the perforating forceps in a very large number of cases. My practice is to use them in order to incise the eyeball, but to lay them aside for the conjunctival forceps in the subsequent steps of an operation; on the ground that the pressure required to give them their hold may do mischief by starting the lens or vitreous body, when once the support of the aqueous humor is withdrawn. I have seen surgeons attempt to use these forceps by pinching up a fold of conjunctiva between their points; but in this way their action is very unsatisfactory, and I mention the practice rather for avoidance than for imitation. The sclerotic forceps have lately been a good deal superseded by the double hook, which is perhaps better for general purposes; but the forceps are invaluable for operations requiring great nicety of incision, as, for example, in removing the apex of a conical cornea. The conjunctival forceps have a special application in the last stage of cataract extraction; when besides fixing the eye, their blunt extremity can be made to exert a carefully regulated pressure which may much promote the exit of the lens; although, under all other circumstances, the exercise of pressure during fixation should be sedulously avoided. In all operations the fixation instrument, of whatever kind, should take its first hold at a point near the corneal margin, opposite to the centre of the projected incision; and it may be afterwards applied wherever circumstances may require. The traction exerted should always be in the direction of that of one of the recti muscles, so as to rotate the eyeball upon its centre, but not to drag or lift it from its place. It is important to be able to release fixation forceps at a moment's notice, as in case of efforts to vomit, or of escape of vitreous humor; and therefore the spring catch, with which they are sometimes fitted, should under all circumstances be discarded. Locked forceps would also be liable to drag or press upon the eye by their weight, and they are too heavy to be passed from hand to hand when in position. Notwithstanding the trifling wounds which they inflict at each closure, the operator must be content to relinquish his hold whenever fixation ceases for the moment to be required.

The ciliary region is carefully shunned by surgeons, on account of the liability to sympathetic ophthalmia which attends upon wounds that implicate it; and the sclerotic behind the ciliary region is only penetrated or incised in a small number of cases. Speaking generally, and as far as the external tunics are concerned, the domain of ophthalmic surgery consists of the cornea and the corneo-scleral junction, perhaps including in the latter an extremely narrow annulus of true sclerotic, which must be wholly anterior to the plane of the front surface of the iris. Wounds of the cornea, which always leave a discoverable cicatrix, sometimes

leave a conspicuous opacity; and the non-vascular membrane does not heal with either the same celerity or the same certainty as the vascular area which surrounds it. Surgical incisions, therefore, are by choice situated in the corneo-scleral junction; but needle punctures, which are insignificant as wounds, may be made in the cornea itself without scruple. It is often necessary to make them there, because it is often necessary to use needles in the pupillary space, either to break up a cataract or to lacerate or detach a film of capsule or false membrane. If this were done from the corneo-scleral junction, the needles could not be directed to the required spot without exerting pressure upon the iris; whereas, from any point of a circle lying about midway between the centre of the cornea and its margin, needles may be passed into a dilated pupil without touching the iris at all. Sometimes, of course, it may be necessary to incise the cornea; but in such case the cutting edge should be used sparingly, and the wound should be as far from the centre as circumstances will allow. In making any puncture or incision, it is necessary to remember that the cornea is laminated, and that its laminæ are parallel to the curvature of its surface. It is not difficult to entangle a point between these laminæ, and to separate them for a considerable space before completely penetrating the membrane. In order to avoid such a mischance, the axis of the sharp instrument must be perpendicular to its point of contact, and must be directed towards the centre of the eyeball, or nearly so, until the anterior chamber is penetrated. Then, if the object is to carry the instrument through the cornea into the pupillary space, the thrust may be continued in the same direction; but at the corneo-scleral junction the direction must be changed, in order to avoid wounding the iris. As soon as the point is seen in the anterior chamber, it must be inclined forwards by a backward movement of the handle, so that the blade, in its further entrance, may pursue a course parallel to the surface of the iris, or even a little advancing from it towards the inner surface of the cornea. The latter direction is especially necessary when the blade is to reach or cross the pupillary area, because then, if inclined ever so little backwards, it may either penetrate the crystalline lens or become entangled in the opposite margin of the pupil. A puncture in the corneo-scleral junction must hence be made with great care and gentleness, not with a hasty thrust or stab, which might drive the point into the iris, or through the iris into the lens, before the operator became aware of what he had done. It is the more important to be careful, because the power to carry a blade safely into and across the anterior chamber depends upon the retention of the aqueous humor. If this is suffered to escape, the iris and lens are projected forwards against the cornea and a knife would be liable to come in contact with them. Eye instruments, as a rule, are made to increase in size from their points backwards,[1] so that they may fill their own incisions completely,

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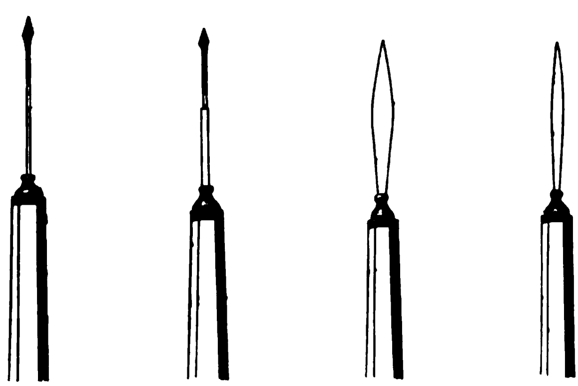
[1] [This is true of knives only, and not of all knives: Von Graefe's linear cataract

and may prevent loss of aqueous humor as long as they are advancing; from which formation it follows that they cannot be partially withdrawn to recover a false step, and then pushed on in another direction. If the point should become entangled in the iris, and cannot be released by a backward movement of the handle, it would generally be necessary to withdraw the blade entirely, and to defer the operation until the anterior chamber had refilled, or even until the wound had united.

The instruments used for penetrating the anterior chamber are of two kinds, needles and knives, and each of these may be subdivided into two classes. The needles are either perforating or cutting, the knives either lance-shaped or linear.

The perforating, or cataract needle, shown in natural size at A, Fig. 43, is of all eye instruments that which requires the most

FIG. 43.



A. B. C. D.

perfect and finished workmanship. It consists of a polished cylindrical shaft, terminating in a fine lance-shaped head, which, within narrow limits, may be larger or smaller according to circumstances. But the head and the shaft must bear such a proportion to each other that the latter may accurately fill the opening made by the former, neither being tight enough to interfere with free movement of the point within the eye, nor loose enough to permit the aqueous humor to escape. A pyramidal shaft, increasing in thickness towards the handle, would soon arrest the onward progress of the point, and would often arrest it prematurely, before the surgeon had carried it as far as he desired. A shaft tapering the other way, or with a flaw in the circularity of

knife, for instance, is of uniform width and thickness throughout the greater part of its length. Of needles, those used in the old operation of couching were made slender in the shank, so as not quite to fill the hole made in the sclera by the lance-shaped point, while needles for operations in which the anterior chamber is entered by perforating the cornea are made with a shank of strictly uniform diameter, and of such size as accurately to fill the opening made by the lance-shaped point.]

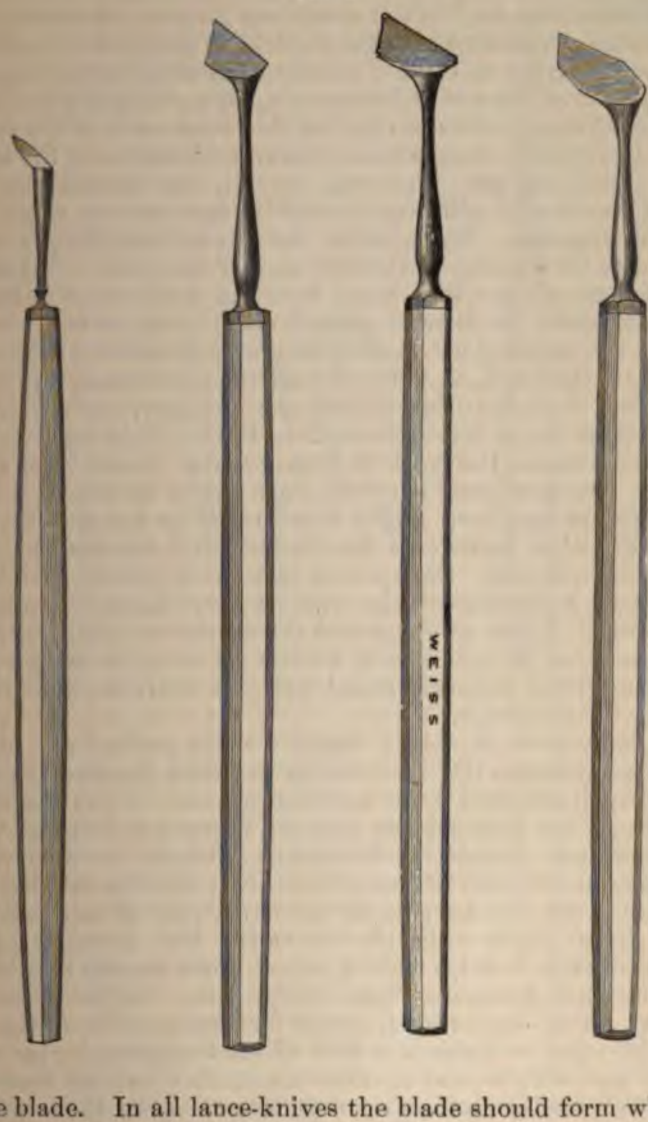
its outline, would allow the aqueous humor to leak out by its side. The shaft is about an inch in length, and is fixed in a slender, smooth, ivory handle, nearly four inches long, and octagonal in section. Upon one of the sides a conspicuous mark—the maker's name or some other, is stamped in black characters—and this side should be in the same position in introducing the needle and in withdrawing it, so that the lance-head may pass out again through its linear wound of entrance, without converting this into a cross-cut, as it would do if its original direction had been changed. Some needles, resembling those above described in other respects, have an abrupt enlargement about the middle of the shaft, as shown at B, Fig. 43. These are called "stop" needles, and the enlargement is intended to prevent them from penetrating too deeply. The contrivance would perhaps be useful if the needles were to be worked by machinery, but for surgically educated fingers it is at least superfluous.[1] The cutting needles, C and D, Fig. 43, are, in fact, very fine two-edged knives, chiefly used for making small incisions through the cornea, or for performing paracentesis of the anterior chamber. The figures represent the maximum and minimum sizes; and, as the blades are straight, they are only available for the temporal side of the eye.

The lance-shaped knives—Fig. 44—are intended to complete an incision by a single thrust. They are therefore two-edged, their sides meeting at an angle proportionate to the width of the blade, which varies according to the length of the intended incision. Sometimes, as in the two central figures, the blades are simply angular; sometimes they are angular in front, and parallel-sided farther back. In a very narrow knife, like that to the left, which resembles a cutting needle, the sides curve from the point into parallelism; but in a broader blade like that to the right the change is abrupt. The object of having parallel sides is that the internal opening may be as large as the external; and, in order that this object may be fulfilled, the anterior or angular part of the blade must not be too long to pass entirely into the anterior chamber of an ordinary eye, so that the parallel part may come into operation. I have seen broad knives in which the maker, desirous to diminish the angle formed by the cutting edges, had lengthened the angular part so much that the parallel-sided part could never by any possibility enter the eye, and might as well have been altogether absent. Very broad blades, therefore, have the manifest disadvantage of large cutting angles, which cause them to encounter increased resistance from the tissues; and they have the additional disadvantage that the extremities of the wounds they make come forward into the cornea, although the centre may

[1] [The stop needle is the invention of Mr. Bowman, and is highly valued by most operators: in operations with two needles the "stop" affords an efficient and convenient means of fixing and steadying the globe. Mr. Bowman has also recommended a form of lance-knife made with a stop, for cases in which it is desired to make two corneal incisions in certain operations for closed pupil.]

be fairly behind the margin.[1] On both accounts they are better avoided, especially as it is not difficult, with a knife of medium width, to enlarge the incision at one end in the act of withdraw-

FIG. 44.



ing the blade. In all lance-knives the blade should form with the shaft an angle of about 150°, so that the handle may clear the upper margin of the orbit or the projection of the nose, and an

[1] [This can occur only when the point of the knife is turned forward into the concavity of the cornea, and it may be prevented altogether by having the flat of the knife slightly hollowed out like a razor-blade.]

incision may be made with equal facility at any part of the corneal margin. In using a lance-knife it is held somewhat like a pen, between the thumb and first two fingers, in the left hand for the temporal side of the left eye or the nasal side of the right, in the right hand for other parts of either. The operator stands behind the head of the recumbent patient, whose feet should be towards a window so that a good light may fall directly upon the face. Having selected a knife of suitable width, its point is to be placed on the eye at a selected spot, about half a line behind the corneal margin, fixation having first been made at the opposite side. The point is then directed towards the centre of the eyeball, and is slowly and gently pressed through the textures by extension of the thumb and fingers, until it can be seen entering the anterior chamber. Then, while the thumb and fingers remain motionless for a moment, the direction of the blade is changed by a movement of the whole hand from the wrist, so as to turn the point forwards. It is next pushed steadily on by continued extension, the operator not looking at the incision, but at the farther margin of the pupil, so as to see that the point clears the iris and glides over it to the other side of the chamber, until an incision of sufficient length has been made. If the blade were then suddenly withdrawn, the aqueous humor would escape with a gush, and the zonule or capsule of the lens might be ruptured by the shock, or the lens itself might be wounded by the receding point. To avoid either occurrence the blade is first loosened a little in the incision, so that the aqueous leaks out quietly, and is then withdrawn, somewhat slowly, with its point directed towards the cornea, until it has safely passed the nearer margin of the pupil. Fixation must be maintained during removal, as otherwise the eyeball might be suddenly rolled upwards by reflex action of the superior rectus muscle.

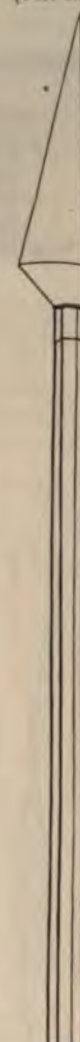
The lance-knife is chiefly useful for the preliminary incisions for operations upon the iris, in cases in which the anterior chamber retains its natural shape and dimensions. When the iris and lens are pushed forwards, as happens in some cases of glaucoma, the lance-knife cannot be introduced without much danger of wounding one or both of these structures; and the incision which it makes is not well adapted for the extraction of cataract.

The linear knife—Fig. 45—is called Von Graefe's cataract knife, although it dates from a period more remote than that of the illustrious ophthalmologist whose name has been conferred upon it. It is single-edged, except for about a line at the point, and is intended to make a section of the ocular tunics by cutting its way out with a sawing movement, after having been introduced by puncture and counter-puncture. Like the lance-knife, it should be entered in a direction towards the centre of the eyeball, and turned forwards as soon as its penetration is complete. It fills its puncture so as to retain the aqueous humor, and may be carried across the anterior chamber very deliberately, but, as soon as its point reaches the place selected for the counter-punc-

ture, it should be pushed through with a quick thrust, and with a slight backward movement of the handle effected by rotation of the wrist. If this is not done, the point is apt to glide a little backwards within the eye, and to emerge nearer the ciliary region than was intended. The blade being straight and of a certain length, all incisions with the linear knife must be commenced on the temporal side of the eye. It is used chiefly for cataract extraction, and for iridectomy when there is no room for a lance-knife in the anterior chamber.

Fig. 45.

[Fig. 46.]



With the blades above described, every incision into the eyeball may be made with facility. There are, however, many other varieties, each with its fancied fitness for some particular proceeding, or with its real fitness for the hand of some particular operator. Beer's knife [Fig. 46], the blade of which is a right-angled triangle, cutting at the acute angle or point and along the hypothenuse, held its ground as a cataract knife for a century, and has only been superseded in our own day since the operation of flap extraction has fallen into disuse. It is a valuable substitute for a scalpel in operations upon the eyelids, especially when it is desired to split the tarsal cartilage into two layers. The knives of Wenzel, of Sichel, of Scott, and of other bygone worthies, are still used by some surgeons, and their shapes may be seen in the shops and catalogues of instrument makers. The essential qualities of an eye-knife are that it should be symmetrical, sharp, rigid, and made of the smallest possible quantity of metal. A blade which is not symmetrical will not fill its puncture, and may allow a premature escape of aqueous humor. A blade which allows no aqueous humor to escape prematurely is an addition to the contents of the eyeball, and the smaller the addition the better. Linear knives, as commonly sold, are both too thick and too broad, and lance-knives are often too thick along the middle, so that both are better after half a dozen grindings than when they were new. Without rigidity the course of the point cannot be accurately determined; for if the blade of a linear knife were to form a curve when the handle was moved backwards, no one could foresee the exact point of counter-puncture. A blunt knife is worse than useless; and the surgeon should always sat-

isfy himself on this score before beginning an operation. The best test is afforded by a piece of very fine kid leather, stretched over the head of a little drum made for the purpose (Fig. 47). When the point of a knife or needle is simply suffered to rest on the kid, it should cut through by its own weight without making a depression, and without sound; and when the knife is held it should not only cut noiselessly, but without conveying any sense of resistance or vibration to the fingers. For the first-named trial the drum must be held in the hand, not placed on a table, as otherwise the point might strike and spoil itself in falling through. With linear or narrow lance-knives or cutting needles it is necessary to test not only the point, but also the whole length of the edge by a drawing cut; and with a two-edged blade this should be done on both sides. Those who neglect this precaution will sometimes find unexpected difficulty in converting an easily made puncture into an incision.

Fig. 47.

Iris forceps are used chiefly for iridectomy, and the most generally convenient model is shown in Fig. 48. The delicate blades are curved near their extremities to form [nearly] a right angle with the rest of the instrument, so that they can be introduced through an incision at any part of the corneal margin. Their little teeth, shown both open and closed at A, B, and C, are not terminal, which would involve a sort of dipping action to seize the iris, but lateral, and on the side of the convexity of the curve, so that the iris naturally tends to rise between them when they separate. When closed, the extremities and the exposed surfaces of the teeth are alike smooth and rounded so that they cannot scratch the edges of the wound or the surface of the iris. [This useful modification of the iris forceps is the invention of Liebreich (*Archives of Ophthalmology and Otology*, I, I, p. 92). Liebreich has also very ingeniously modified the mechanism of the iris forceps (Fig. 49), enabling it fully to take the place of the complicated canula forceps of Desmarres (Fig. 50). We presume this is the instrument condemned by the

Fig. 48.

[Fig. 49.]

author in the last lines of this paragraph, a judgment in which we cannot concur.] The canula forceps (Fig. 50), have the advantage of requiring only a very small wound of entrance, notwithstanding which they expand freely within the eye. They are chiefly used for the removal of shreds of opaque capsule, or of false membrane, from the pupillary space; and a single handle may be fitted with blades of different lengths and different widths of opening, some with lateral and some with terminal teeth. By pressing the trigger on the handle, the canula is pushed forwards, the blades are closed, and the instrument, reduced to the dimensions of a fine probe, may be introduced through the puncture made by the smallest cutting needle. When the pressure on the trigger is relaxed, the canula recedes and the blades expand, to be again closed upon anything which is presented to their grasp; and in the meanwhile the canula will, partly at least, prevent the escape of aqueous humor, so as to allow the instrument to be freely moved within the eye. A clumsy substitute for the canula forceps, lately invented, is inferior to them in every respect but one, even in the best form which has been given to it by English makers. Its solitary apparent advantage is that it can be made to enter the eye from the nasal side; but even this is only of colorable utility, as the canula forceps can almost always be carried across the chamber to any point where they are required.

FIG. 50.

Scissors are of various shapes, and are used for cutting the iris, for enlarging incisions in the cornea or at its margin, for dividing the conjunctiva and tendons in strabismus and in enucleation of the eyeball, and for dividing the optic nerve in the last-named operation. For cutting the iris they are usually angular, as at A (Fig. 51). Some surgeons like them probe-pointed on one or both blades; I prefer to have both blades as fine and sharp as possible. For all the other purposes they should be curved on the flat (B, Fig. 51), and should have points which are hardly blunt, but with just sufficient roundness and smoothness to glide easily over the sclerotic, between it and a tendon, or to pass between the cornea and iris without injuring either. The keenness of scissors is best tried upon a piece of the thinnest tissue-paper, well wetted; and they should cut this cleanly, quite up to their points, without bending or folding it in the least. They should also, as cutlers say, work "sweetly;" that is, they should convey to the fingers, during slow closure, a uniform sensation of smooth, clinging contact between the edges, from heel to point, without grating or harshness. If they grate, the fault may often be corrected by drawing the thumb-nail, or in very fine scissors the pulp of the thumb, with a

gentle pressure along the inner aspect of each blade, so as to turn the edges outwards.[1] Scissors are of all instruments the most difficult to keep in order, because they often become bloodstained and require to be washed, and then a little moisture is apt to remain between the blades near the rivet, and to produce rust,

FIG. 51.

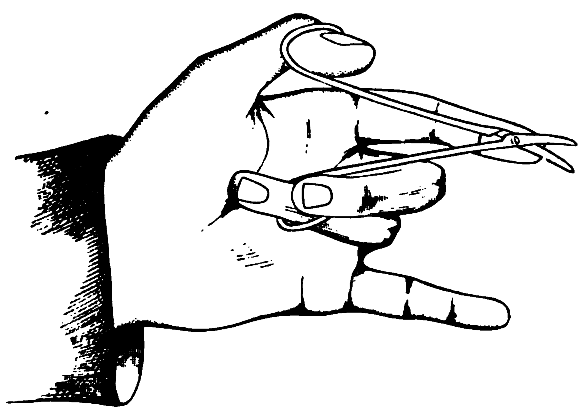
A B

which throws them out of gear. They should always be carefully examined before use, because it is very unfortunate when they close upon the iris without dividing it, and still more so when they retain it between their points after the fashion of forceps. The best way to take care of them is to apply a minute quantity of watchmaker's oil to their joints; and, after use, to wash them in boiling water, which renders the metal sufficiently hot to dry itself completely after being wiped.

[1] [The edges of the blades of scissors must not turn outwards, even in the slightest degree, for in that case they will not cut; on the other hand they should not turn inward, lest they grate in working.]

For use in the left hand, ordinary scissors require a special form of manipulation. They are so made that the natural opponency of the right thumb and medius brings their edges into opposition, while the left thumb and medius tend rather to separate them. When they are to be used in the left hand, the thumb should pass through the upper loop, and the ring finger through the lower, as shown in Fig. 52. The medius should rest in front of

FIG. 52.



the lower loop, and in firm contact with it, and the point of the index against the lower blade, a little in front of the joint, and should there make pressure. Thus held, scissors will cut to the points as well in the left hand as in the right. For excising a portion of iris, it is generally possible to take the scissors in the right hand for either eye; but for enlarging the right-hand extremity of a wound in the corneal margin, for strabismus operations on the left eyelids, the mastery of scissors with the left hand, if not essential, is often conducive to neatness and dispatch. Daviel invented the two pairs of scissors called after his name, for enlarging the section in flap extraction of cataract; and one of these pairs is expressly shaped for left-handed use. We are indebted to Dr. Noyes, of New York, for the scissors shown in Fig. 53, in which the ordinary looped handles are replaced by springs, and the blades are opened and closed by simply making and relaxing pressure. This form may be used equally well in either hand, and is very convenient for excising the iris, as well as for other purposes.[1]

Besides the foregoing instruments, there are many more which form part of the equipment of an ophthalmic surgeon; but, while those already described are of general applicability, so that a

[1] [De Wecker's ingenious iris scissors, illustrated in chapter viii, may very well replace those shown in Fig. 53.]

knowledge of their peculiarities and uses underlies the principles of the art, the remainder, generally speaking, are each employed only for some single purpose, and will be best described when that purpose is itself under consideration.

In weighing the circumstances which may render an operation upon the eye expedient or necessary, or which may conduce to a successful or unsuccessful issue, it is necessary to remember the twofold character of the organ; first, as a living part of the human frame; secondly, as an optical instrument. An operation performed for the restoration of sight cannot be said to fail surgically unless, by delayed healing or subsequent inflammation, the textures of the eye are injured or destroyed. But, however complete the surgical success, the operation fails optically if sight is not restored; and, while the chances of surgical success can generally be determined beforehand with great precision, the optical success may depend upon conditions the presence or absence of which it is not possible to ascertain with exactness. For instance, I was lately consulted by a young lady, one of whose eyes had been destroyed, and the other greatly injured, by purulent ophthalmia in infancy. In that which was only injured the cornea had been perforated by an ulcer, and much flattened during the healing process, while a great part of the margin of the pupil had become adherent to the cicatrix. Most of the cornea was clear, and there was a very small pupillary opening. The eye was in constant movement from nystagmus, but the patient could find her way about and could read letters of large type. Now in this instance an iridectomy for the formation of an artificial pupil was almost certain of success surgically; but its optical success was very doubtful. The chances of loss of the eye from inflammation or suppuration after the iridectomy were so small as scarcely to have any appreciable weight; but, assuming the healthiness of the retina, the amount of improvement of sight would still be determined by the degree and kind of alteration in the shape of the cornea, by the state of the crystalline lens, and by the disturbing effect of the nystagmus. None of these elements could be estimated excepting by actual trial after an operation; and the only opinion which could be given previously was that the case was one in which an artificial pupil might be safely made, and would possibly be productive of much, almost certainly

FIG. 53.

of some, improvement of visual power. In a general way, the surgeon is first called upon to estimate the surgical risks of a proposed operation; and next to consider what amount of optical gain will be likely to follow surgical success. It is necessary, of course, to take into account the presence or absence of any progressive changes within the eye; because there are some states of chronic inflammation, tending to go on from bad to worse, in which an operation may not hold out any brilliant prospect either surgically or optically, but in which, nevertheless, it may be the only course which holds out any good prospect at all. But apart from cases of this kind, the surgeon should usually be able to lay before his patient an opinion first as to the probable safety of an operation, next as to the probable benefit to be derived from it; lastly, as to the tendencies of the case if nothing is done. In a case of uncomplicated cataract, for example, it would be fair to say that an operation afforded the only prospect of escape from blindness, that the chances of surgical success were at least nine to one of failure,[1] and that surgical success would bring optical success in its train. In a case of partially detached retina, it would be fair to say that an operation would be wholly free from surgical risk, but attended by only a slender prospect of optical success. In a case of glaucoma, as long as any vision remains, it may generally be said that the surgical risk is inappreciable, and that some degree of optical success is almost certain; while, if nothing is done, incurable blindness will be the only possible issue. If matters are stated to a patient in this way, and the several elements which enter into the case are separated for his consideration, he will generally have no difficulty in deciding upon the course which it will be best for him to pursue; whereas, unless he is informed that the questions of surgical and of optical success are to some extent distinct, he will occasionally be disappointed by the results of even the most judiciously planned and most skilfully performed operation.

There could be few greater benefactors, if not exactly to the human race, yet at least to the numerous class of ophthalmic patients, than he who would invent and bring into general use a new word by which to express the dealings of surgery with the eye. To the public generally an "operation" suggests something after the manner of a thigh amputation in the days when there were no anæsthetics; and many persons shrink from the mere sound, without considering how little it may mean. An incision which cannot attain a maximum length of half an inch, which cannot involve danger to life or limb, and which at the worst can only fail in attaining a desired end, is not a matter that need excite much apprehension; and these conditions are fulfilled in

[1] [In 2124 extractions reported by Arlt, a satisfactory visual result was obtained in 1726 (81.26 per cent.): 256 others (12.05 per cent.) were recorded as unsatisfactory, but with a prospect of being made satisfactory by a secondary operation: 142 (6.69 per cent.) were total failures.—Arlt, *Graefe und Saemisch*, *Handbuch*, III, pp. 217–219.]

probably 90 per cent. of the instances in which an operation upon the eye is recommended. In a small proportion of cases, an eye with defective sight is exposed to some danger of losing what it possesses, in the hope that it may obtain much more; but this should scarcely ever be done unless there are two eyes to deal with, of which only one is put in jeopardy; and never unless the probability of benefit far outweighs the probabilities of mischance. While, therefore, it is always necessary to state risks clearly and fairly, and to remind a patient that every human action may have two issues, still the proper attitude of mind towards ophthalmic operations is to consider it a ground for congratulation that a case admits of surgical interference, and not a ground for condolence that it requires it. In order that this attitude of mind may be maintained, and generally recognized as an appropriate one, it is incumbent upon surgeons to be sure of the reasons which lead them to advise an operation, and to be explicit with regard to the prospects which attend it; so that, whatever may be the result, the patient may always feel that he has been treated with candor, and has not been induced by overwrought expectations to submit to a procedure from which he has failed to derive advantage.

It can hardly be said that operations upon the eye require any kind of preparation. When the flap extraction of cataract was generally practiced, it was held to be important, on account of the size of the corneal wound and of the necessity of maintaining perfect coaptation of its edges, that the patient should be kept for twenty-four hours or longer in almost absolute rest, and especially without action of the bowels, for fear of the possible effects of straining. It was therefore customary to administer a laxative on the day before the operation, and to give afterwards a small dose of opium, or of some equivalent medicine, by which the necessary quietude might be secured. For the same reasons cough was held to be almost prohibitory of cataract extraction, and to be a malady which must be subdued or cured before the operation could be undertaken with prudence. The smaller and differently situated incisions of the present day render these precautions well-nigh superfluous; and although no one without urgent necessity would operate upon a patient with loaded bowels, or who was disturbed by paroxysms of coughing, yet either of these conditions must be of a declared character in order to be regarded as a positive obstacle. In a general way it may be said that any patient who is in fairly good health, as measured by his own personal standard, is fit at short notice to undergo any eye operation which his case may require; and I myself greatly prefer to abbreviate as much as may be possible the stage of anticipation, the time during which something is impending. When delay is necessary on other grounds, the interval may be usefully employed in endeavors to improve the general health; but it must be remembered that anxiety is one of the most potent agents in the production of depraved or perverted nutrition, and that anxiety arising from fear of blindness is apt to be of an exceedingly oppressive character. There

are many cases in which the knowledge that an operation has been done and is over, and that there is every prospect of its being successful, will be the most potent tonic that can be administered, one which will do more to clean the tongue, to restore appetite and digestion, and to give refreshing sleep, than all the drugs at the disposal of the physician. There are some conditions, moreover, in which an operation removes a source of irritation, and in these all unnecessary delay is strongly to be deprecated. If, for example, an eye is inflamed or painful by reason of the pressure of a displaced or wounded lens, it will be worse than useless to employ antiphlogistic or sedative treatment, as long as the cause of the disturbance is permitted to remain unremoved.

The season of the year in which operations upon the eye are performed does not exercise any appreciable influence upon their success. In former times it was customary to avoid the extraction of cataract during the winter months; but this precaution has long been laid aside, and experience has shown that it was an unnecessary one. Operations upon the iris may be done at any time, and are often matters of urgency which must be done whenever the need for them arises. Operations for cataract are often performed upon aged and feeble patients; and for these some circumspection is required. It would be unwise to operate during the prevalence of intense cold, or even during the first days of sharp frost, when the circulation of old people is apt to be depressed, and their powers of healing are reduced in proportion. It would be unwise to operate during excessive heat, which relaxes the skin, renders old people irritable and restless, interferes with sleep, and impairs appetite. Other things being equal, it is best to operate when there is a reasonable prospect of the patient being able to go out of doors during the period of convalescence. With due regard to such considerations as these, there is really no reason for preferring May to November; and statistics on the largest scale show no differences between the results of one month and those of another.

The position of the patient has already been referred to incidentally, but it is a matter which requires more detailed mention. He should lie flat upon his back, with pillow enough to render the plane of his face horizontal, or even to raise the forehead a little above the level of the chin. The feet should be towards a window, through which the direct rays of the sun are not shining, so that diffuse daylight may fall full upon the face. When this cannot be arranged, the window may be on the right-hand side for the right eye, and on the left-hand side for the left, so that the shadow of the nose may not interfere with the illumination. The height of the couch should be such that the operator reaches the eye with comfort, neither stooping over it nor being himself too low; and the width should be such as to afford free access to the patient on all sides. In a private house, the best couch is generally formed by two small tables put together, with a folded blanket as a cushion to lie upon, and a single pillow. The length should be such as to

support the whole frame; but there is no great harm in suffering the feet to overhang. A bed is generally less suitable, because the head or foot rail would be in the way of the operator; and when the patient is laid across a wide bed the face is inconveniently low, and it is difficult for the assistants to gain ready access on either side. For most operations the surgeon, if ambidextrous, stands behind the patient's head, directly facing the window. The assistant, who may be required to perform fixation, should stand on the side of the eye under operation, about the level of the patient's chest; and the administrator of chloroform or ether on the opposite side. If the surgeon is not ambidextrous, he must vary his position as circumstances may require; and his assistants must be guided by his movements.

The surgery of the eye, like that of other organs, is largely indebted to the employment of anæsthetics for the perfection to which it has been brought. The popular notions of the sensitiveness of the eye, depending, as they do, upon the sensitiveness of its surface to mechanical or chemical irritants, are greatly exaggerated; and the operations are in truth not very painful. The advantages of an anæsthetic are almost entirely due to the way in which it facilitates fixation, and other means of obviating the instability of the globe; and to the way in which it overcomes the tendency to contraction of the recti and orbicularis muscles. The superior rectus muscle holds a specially protective relation to the eyeball, by virtue of a reflex or automatic action which is quite beyond the control of the will. By this action, during sleep, the cornea is rolled upwards; and the same movement occurs upon the first warning of danger. So prompt is it, that in a case in which a seated person was stabbed with a penknife by one who was standing over him, the blade, although it passed through the upper lid, penetrated the sclerotic below the cornea. A glance at Fig. 1, page 19, will show that when once the external ocular tunic has been divided in front of the iris, and the aqueous humor evacuated, the delicate membrane called the zonule of Zinn (z z) is all that prevents the escape of the lens and of the vitreous humor; and this membrane would be ruptured by a very small amount of muscular effort. In the cataract extractions performed prior to the use of chloroform a definite percentage of failures was traceable to this cause; the puncture and counter-puncture producing muscular spasm which ruptured the zonule, forced out the vitreous after it, and sometimes half emptied the globe. The operator was supposed to wait, before completing his section, until all muscular spasm had subsided; but this was not always possible in practice, and the injury was doubtless frequently done whilst the knife was still in the eye. Fixation was especially dangerous under such circumstances, because it was almost sure both to excite and to maintain reflex muscular contraction; and a continuing irritation, which the effort of the superior rectus fails to shake off, is likely to produce spasm of the other recti muscles also, and hence general compression of the

eye. Without fixation, it is hardly possible deliberately to select the points of puncture and counter-puncture, inasmuch as jerking movements of the eyeball are apt to follow the first contact of any sharp instrument; and almost the only exception to this statement is when the puncture is made at the outer part of the horizontal meridian, and when, a speculum being dispensed with, the globe is steadied by counter-pressure with the fingers. But operations at the upper margin of the cornea, such as iridectomy and the modern forms of cataract extraction, may be said absolutely to require the speculum and fixation; and although they may be successfully accomplished without an anæsthetic, yet they are then unnecessarily difficult, and are attended by an abnormal percentage of failures and disasters. For a long time the employment of chloroform was resisted by ophthalmic surgeons, on account of the vomiting which it occasions in some persons. It was feared that this vomiting, especially after cataract extraction, might itself produce expulsion of the vitreous, or even hæmorrhage within the eye; but it has been found in practice that the dangers of sickness are far less than those of irregular muscular contraction. By proper precautions, sickness during or after anæsthesia can be prevented in the great majority of cases; and it never occurs without warning. In the course of an operation, if sickness is seen to be imminent, the surgeon should desist, should remove the speculum from between the lids, cover them with a ball of soft sponge or cotton-wool, and make gentle pressure upon this with the palm of his hand, so as to support the eye until vomiting has ceased. In the meanwhile the patient should be rolled over upon his side, and from this to a semi-prone position, so as to facilitate the escape of anything which is ejected. As soon as there is a lull in the sickness the patient may be again turned upon his back, the anæsthetic again administered, and the operation proceeded with. Muscular spasm differs from sickness in these respects, that it is more dangerous when it occurs, that it occurs without warning, and that external support is of less avail against it. Taking operations all round, it may fairly be said that a passive eye is the first condition of facility to the surgeon, and of security to the patient. I do not think that the refusal of a patient to take an anæsthetic would justify a skilful surgeon in refusing to perform any operation upon the eye; but it would certainly entail upon him the duty of explaining that the chances of a successful issue would be seriously diminished. [It is the conviction of many good surgeons that, with patients of average self-control, most operations, including iridectomy and cataract extraction, may be performed as safely and as well without anæsthesia as with it; the question of the administration of an anæsthetic, and we agree with the author in preferring ether, may be decided in each case for itself, as the good judgment of the surgeon may dictate.]

The unpleasant effects which attended upon the use of ether at the time when it was first given as an anæsthetic, led Sir James

Simpson, as is well known, to suggest chloroform as a substitute for it; and this agent for many years held its ground very firmly in England. But there is a grave objection to chloroform in its occasional tendency to produce death; a tendency which is often foreshadowed, in aged people, by great pallor of the surface and depression of the heart's action. On this account there has been for some time past a disposition to return to ether; and it has been largely used in general surgery at St. George's Hospital, since 1871. Mr. Warrington Haward, who was then surgical registrar there, and by whom it was reintroduced, gave it for me to several patients; but we were both of opinion that it failed to produce the complete muscular relaxation which is so necessary for operations upon the eye, and we returned for a time to chloroform. In 1872, however, the occurrence of several deaths from chloroform strongly directed attention to the subject; and in the same year Dr. B. Joy Jeffries, of Boston, U. S., read a paper before the International Congress of Ophthalmology, in which he maintained that ether was not only a perfectly efficient anæsthetic in ophthalmic surgery, but also that it was absolutely safe. To my objection that it did not sufficiently relax the muscles, Dr. Jeffries replied that this was a question of the mode of administration; and he assented to my request that he would come to St. George's Hospital to give an illustration of the mode which he employed. He administered ether to five or six patients in succession, and their complete passiveness left nothing to be desired; insomuch that I extracted cataract from both eyes of one of them, without being reminded of the existence of the recti or the orbicularis. This excellent result was due to the freedom with which the ether was employed. We had formerly given it in measured drachms and half drachms, as carefully as if it had been chloroform. Dr. Jeffries made an inhaler by folding a towel into a large cone and placing a sponge in its apex. He then poured in ether with a free hand—an ounce or two ounces at a time—covered the lower part of the face with the mouth of the cone so as to exclude air, and let the patient fill his lungs with almost undiluted ether vapor. Any attempt to struggle at the commencement of the inhalation was restrained; and complete quiescence was produced in from two to four minutes. If the face became livid, this was attributed to the absence of air rather than to the presence of ether, and the cone was lifted to allow one full inspiration of air to be taken. The pulse never flagged, and the surface never became pale; and Dr. Jeffries quoted a very large American experience to show that the use of ether in this manner was perfectly free from risk, and that it had no tendency to produce death. We have ever since used it for the ophthalmic operations at St. George's Hospital, in what is practically the same manner, with perfectly satisfactory results as regards the muscles, and without the appearance of any symptom to indicate a possibly prejudicial action. In lieu of the folded towel, we employed for some time a cone of thick felt, covered with waterproof

tissue; and we have since received from Mr. Hawksley the excellent inhaler shown in Fig. 54. This consists of a glass vessel, A, capable of holding ten ounces of ether. B is an inlet valve for air, and its sliding tube is graduated in ounces for the purpose of measuring the quantity of ether consumed. The pipe C D conveys the vapor to the face-piece F, the edge of which is surrounded by a water-cushion to secure exact adaptation. E is a shutter valve for regulating the admission of air either at the beginning of an operation or during its course. The pipe I, furnished with the valve H, conveys the expired vapor to the floor. In use, the vessel A is half

FIG. 54.

immersed in water heated to 100° Fahr., in order to promote a more rapid and equable evaporation of the ether. For this purpose the metal case in which the apparatus is packed is used as a water-bath, and is provided with a cell to hold the vessel A. Ether boils at about 90°, but before the quantity contained in the vessel A has reached that point, the temperature of the surrounding water will have fallen. The time required to produce insensibility to pain is from $3\frac{1}{2}$ to $4\frac{1}{2}$ minutes, and about an ounce of ether is used in a quarter of an hour. The great merit of this inhaler is that the tube from the mouthpiece conveys the exhaled vapor to the floor, so that it is not diffused in the air around the heads of the operator and his assistants. For a single operation this is unimportant; but in a hospital, where eight or ten patients follow each other in rapid succession, the arrangement is highly conducive to the comfort of the surgeons. Except for occasional use in young children, or as a preliminary to the administration of ether, I may say that I have now wholly discarded chloroform as an anæsthetic; and that I have so discarded it on the ground insisted upon by Dr. Jeffries, namely, that occasional deaths are inseparable from its employment, and that there ought to be no deaths in ophthalmic surgery. On account of its more pleasant flavor and more subtle

action, chloroform is more easily administered to young children than ether, and for them I believe it is safe. But after ten or eleven years of age I seldom venture upon it; and I find that a pure washed ether, such as can be obtained from any chemist, is a perfectly effectual agent, and one which leaves the mind of the operator undisturbed by the risks and uncertainties attendant upon the use of chloroform. I am now in the habit of telling my patients that the necessary anæsthesia is absolutely without danger; and I find that in aged and feeble people, the ether, instead of being a depressant, is a powerful stimulant, and leaves the patient in a better condition for healing than before its administration. If given sparingly, ether is both troublesome and ineffectual; but when the system is, so to speak, drenched with the vapor, its action leaves nothing to be desired.

During the first two or three inspirations ether is apt to give rise to struggling, which seems to depend upon the sense of impending suffocation due to the deprivation of air, before the anæsthetic has had time to produce a comparatively torpid state of the nervous system. When there is plenty of help at hand, as in a hospital, the struggles may be restrained by assistants, and the patient will not remember them after the operation. Mr. Hawksley, whilst the apparatus above mentioned was in course of construction, inhaled ether repeatedly, and he tells me that the tendency to struggle was quite uncontrollable by any effort of his will. But the distress in which it had its origin was relieved by a single full inspiration of air, and did not recur. He therefore made in his inhaler (at E) an aperture of the full diameter of the trachea, which can be opened and closed instantaneously by a sliding ring; and he recommends that this aperture should be completely uncovered as soon as struggling begins, and closed again as soon as one complete inspiration has been taken. I have found this plan effectual in many cases, but not in all; and it is useless to admit air often, since by doing so the effect of the ether is delayed and impaired. Dr. Wharton Hood frequently precedes the ether by a little chloroform, administering enough of the latter agent to impair the acuteness of sensation, but not enough to approach the confines of danger, and then completing the anæsthesia by a full dose of ether given in the ordinary way. This plan greatly diminishes the tendency to struggling, and answers extremely well. Mr. Clover uses nitrous oxide in the same manner; but of his method I have no personal experience.

In some persons, ether produces a rather copious flow of saliva, which is apt to collect in the mouth and throat and to occasion noisy efforts for its expulsion, but which is never a source of more than inconvenience. In a long operation it may be desirable to remove this saliva from time to time; but in ophthalmic surgery it may generally be neglected. Sickness is produced in some cases; less frequently, I think, than by chloroform; but still often enough to be provided against as a probable complication of affairs, so that, except on an emergency, ether should not be given when the stom-

ach contains food. In private practice I generally operate early in the morning, when no food has been taken since the night before; and in hospital, where I operate between one and two o'clock, the patients have nothing subsequent to a breakfast at seven. Under such circumstances any vomiting which may occur is usually trivial in severity and duration. Its occurrence calls for the ordinary precaution of supporting the eye while it continues, and until the hand can be replaced by a well-applied compresive bandage.

Of the various new ethers which have been introduced into practice by Dr. B. W. Richardson I can only speak from an experience too limited to be trustworthy. In Dr. Richardson's own hands, and also in those of Mr. Woodhouse Braine, I have seen them act perfectly well, producing complete unconsciousness and relaxation of muscle without either struggling or sickness, and without unpleasant symptoms of any kind. But I cannot judge how far such results may have been due to the qualities of the agents employed, how far to specially skilful and careful administration, or how far to the state of the patients themselves. Common ether acts quite as pleasantly in a large proportion of cases; and if I had only seen it given to a few persons I might have remained ignorant of effects which it sometimes produces.

Whatever may be the anæsthetic employed, the surgeon should be careful to satisfy himself that its influence is sufficiently profound before he commences an operation upon the eye. In some patients, and especially in nervous and excitable women, a period of struggling is often preceded by a period of deceptive calm, during which the conjunctiva, or the margin of the eyelid, may be touched without any reflex movement being produced. It is always necessary to be suspicious of apparent loss of sensibility after only a few inhalations; for a stage of excitement is almost sure to follow before real and lasting unconsciousness occurs. Especially is it necessary to be careful if the inhaler should be in the way of the operator, so that it must be removed for a moment, and air suffered to enter the respiratory passages freely. The sudden and abrupt reflex movements, utterly uncontrolled by the will, which may follow the division of a nervous filament when the patient is semi-conscious, are far more dangerous than any spasm which would be likely to occur in the normal state; so that imperfect anæsthesia is worse than none at all. The operator should observe: first, that the anæsthetic has been given in sufficient quantity and for a sufficient time; next, that the orbicularis muscle does not react on the speculum; lastly, that the application of the fixation instrument is not followed by reflex movement. Even when these conditions are fulfilled, it is sometimes well to request the assistants on either side to take hold of the lobes of the patient's ears, so that they may restrain any sudden roll of the head at the moment when the knife first penetrates. A small roll should be a matter of indifference, because the hand of the operator, resting by its ulnar margin upon the head of the patient, will accom-

pany it undisturbed over a considerable range of movement. The late Mr. Laurence invented a machine which he called a cephalostat, and which rendered any rotation of the patient's head impossible. It was a sort of vice, consisting of two padded side-plates capable of being approximated by a screw. The head could be released from the absolute grasp of the instrument in a moment; but the side-plates were much in the way when it became necessary to turn the patient upon his side on account of sickness. Such an appliance, moreover, cannot be conveniently carried about to private houses; and a surgeon must learn to accommodate himself to the most adverse conditions under which he is liable to be required to exercise his calling.

An operation being completed, it is next necessary to secure the most accurate possible coaptation of the edges of the wound, and to see that they are not separated by coagula, by fragments of lens matter, by protrusion of the vitreous body, or by prolapse of the iris. The methods of dealing with lens matter, and with vitreous, will be described when cataract operations come under discussion; but coagula may be carefully removed by fine forceps, and prolapse of the iris may generally be reduced by gentle circular friction over the wound, through the closed lid. Blood which is entirely within the anterior chamber may be left for absorption; but blood between the lids should be gently taken up by the point of a fragment of sponge, and coagula in the same situation should be removed by forceps, as well as any that may cling about the cilia. While all this is being done, it is most prudent to maintain anæsthesia, so as to prevent the possibility of harm from any sudden contraction of any of the ocular muscles. The edges of the wound being in contact, and the eye properly cleansed, the compressive bandage described at page 134 should be applied with moderate firmness, and somewhat more firmly than usual if there is any tendency to sickness. Air should then be freely admitted, and the patient should be removed to bed as soon as consciousness is sufficiently restored.

With regard to subsequent treatment, there is nothing of general application except that pain must be subdued and sleep encouraged. To this end, the patient should be visited in the evening, and the state of the bandage examined. Usually there will have been some exudation or discharge, and the linen covering the eyelids will feel stiff and uncomfortable. When this is the case, or when there is a consciousness of pressure on any single point, as contrasted with a sense of general support, the bandage must be removed and reapplied, generally without opening the lids. At the same time the hair should be combed and arranged, because disorderly hair is always uncomfortable under a bandage. If a nightcap is worn, the bandage should be applied outside it; and a few stitches may be inserted here and there to prevent the folds from being displaced. The same end may be attained by slips of gummed paper, wetted and pressed upon the folds—an excellent device with which I was made acquainted by Mr. Fuller. If there

is pain, some form of opiate should be prescribed, to be taken at regular intervals until relief is obtained. If there is no pain, the patient [if in the habit of drinking wine or spirit], may generally take a little wine and water, or spirit and water, according to circumstances, as a night draught; and it is usually prudent to prescribe also a dose of chloral hydrate to be taken only if natural sleep should not be obtained. It is often a good precaution, especially after cataract operations, to limit the movements of the hands by a piece of tape passing behind the back, and with one end tied round each wrist. The tape should be long enough to allow the patient to assume any habitual position; but not long enough to allow a hand to reach the eye during sleep.

The administration of food and drink must be governed by the presence or absence of any tendency to sickness when the state of anæsthesia has entirely passed away. As long as sickness continues, it is well to give nothing but fragments of ice. When it ceases, the kind and amount of nourishment must depend upon the state of the patient and the discretion of the surgeon; but it will seldom be prudent to depart at all widely from customary habits.

CHAPTER VI.

DISEASES OF THE EYELIDS.

The outer surfaces of the eyelids, as parts of the common integument of the face, may participate in most of the diseases affecting the skin to which the face is liable, especially in erysipelas, frontal herpes, and infantile eczema; and may be the seat of warts, nævi, and other growths of various characters. With these conditions the ophthalmic surgeon has no special concern, unless it be with reference to the ocular disorders by which frontal herpes is usually attended or complicated, and which will receive notice in their proper place. In dealing with warts, nævi, or superficial tumors, it is necessary to remember that the production of deformity of the lids, either by the contraction of cicatrices or by the removal of parts, is a matter to be avoided with the most sedulous care, since it must almost always produce some loss of due protection to the eyeball, or must expose it to some more or less hurtful friction. On this account it is generally desirable to attack growths on the eyelids, if they show tendency to increase,

whilst they are still small, so that they may be removed or destroyed with the least possible sacrifice of skin. Small or superficial nævi may generally be successfully treated by the actual cautery, Mr. Wordsworth's needle, shown in Fig. 55, being the most convenient instrument for the purpose.[1] It should be held in the flame of a spirit-lamp until the bulb is of a dull-red, and then, as the red is passing into black, the point should be made to penetrate a line or so into the affected skin, which should be dotted over with such punctures, placed about a line apart. If the nævus is at all large, it is undesirable to inflict upon a young infant the extensive burn that would be caused by dealing with it all at one sitting. The cautery should not be applied on any one occasion over a surface more than half an inch square, and the part in which the nævus is growing most actively should be that first selected. A subcutaneous nævus may often be dissected out entire; but when this is not practicable, or when the skin is implicated as well as the deeper parts, the best treatment is to pass threads of silk through the growth in various directions, and to leave them to excite suppuration. When they do this they may be withdrawn. In order to avoid bleeding, the threads must be thick enough to fill the track of the needle, and they may also be steeped in solution of perchloride of iron. The plan of injecting solution of perchloride of iron into nævi is one that I mention only on account of the great danger attending it. Several cases are now on record in which such an injection has proved immediately fatal; and one of these happened, several years ago, in my own practice. A nævus should never be injected unless it can be completely isolated, either by a ligature or by ring forceps, so that nothing can pass out of it into the general circulation; and whenever this condition can be fulfilled the growth is generally amenable to better methods of treatment.

FIG. 55.

Whatever plan of exciting inflammation in a nævus may be adopted, whether the actual cautery, or setons, or any other, its use must be repeated from time to time until all tendency to active growth is arrested. When this is done, the nævus will begin to shrink and dwindle, will lose its active blood-supply, and will either be entirely removed by absorption in the course of time, or may be removed eventually by the knife as a passive and non-vascular tumor. In the case of a child, whatever the existing amount of disfigurement, the surgeon may always hold his hand as soon as growth is arrested and degeneration begins, and in many instances time alone will remove the disfigurement and complete the cure.

In some cases large and actively growing nævi pass into the stage of degeneration spontaneously, or from the pressure of the

[1] [The galvanic cautery often answers admirably.]

surrounding tissues. A young man presented himself at St. George's Hospital, two or three years ago, with his right eye projected forwards, and forming the apex of a considerable tumor, of which the margin of the orbit, itself greatly enlarged, was the base. The eyelids were much hypertrophied and thickly fringed with long and stiff cilia. The eyeball itself was larger than its fellow, immovable, and with very defective vision, due to retinal changes. The patient was nineteen years old, and he said that the enlargement had not increased, excepting with his growth, since he was three years old; but the deformity was so hideous that he was very anxious to have something done for its relief. I made an incision along the lower margin of the orbit, and soon came down upon a mass of degenerated nævus, which had almost the feel and aspect of condensed lung. I succeeded in removing the whole of it, and the wound healed by the first intention. The eyeball went back into the orbit, and the remaining disfigurement, which was due only to the hypertrophy of the lids and globe, was trivial when compared with the original condition. A year later I saw the patient again, and still further improved his appearance by uniting the external half inch of the enlarged palpebral opening, so as to render it equal in size to the other, and partially to conceal the prominence of the big eyeball. The inferior rectus muscle had either undergone absorption during the growth of the nævus, or was removed during the operation (although I saw no trace of it), for the eye is still immovable in a downward direction, although it follows its fellow in every other. The cornea is clear, and the iris natural, and the state of the patient would no longer excite remark.

In attempting to remove a subcutaneous nævus from the eyelid, or in making the first incision for the exposure of any other kind of tumor which it is desirable not to wound, it will be found better to use scissors than a scalpel. The skin of the eyelid cannot easily be rendered sufficiently tense to cut down upon, and the knife is apt to penetrate more deeply than the operator desires. But if a small puncture is made in the first instance, one blade of fine probe-pointed scissors will run easily through the lax subcutaneous tissue, lifting the skin from the parts beneath as it proceeds, and making an incision which is absolutely at the will of the surgeon. For subsequent dissection a scalpel is more available; but even then the scissors are the preferable instrument. It is worthy of note that wounds of the eyelids, generally speaking, heal with extraordinary readiness. Even a long incision, through which an enlarged lacrymal gland or a considerable orbital tumor has been removed, will almost always unite in a few hours, without the formation of a drop of pus. In order to bring about such a result, the edges must be retained in perfect apposition by a sufficient number of sutures, and the wound then sealed by collodion, styptic colloid, or some analogous preparation. Very fine silk answers well for the sutures; but the best material is the finest platinum wire, as fine as human hair, or, when this is

not at hand, human hair itself, which has the single disadvantage of being less easy to tie. The best needles are those sold for threading the smallest beads. They are so fine as to pass readily through the tissues, and, with wire or hair, they leave no trace of where they have been. The smallest surgical needles are coarse by comparison, and make wounds unnecessarily larger than the delicate sutures which should be employed.

[Very fine black silk, or a single strand of coarser silk, is an entirely satisfactory material for sutures, whether in the conjunctiva or in the skin of the eyelids. The finest glovers' needles, which are made for sewing thin leather, are preferable to ordinary sewing needles; they may be easily bent to any desired curve by first drawing the temper, which is conveniently done by laying the needle, for a few moments, upon a bar of iron heated to dull redness. Sewing needles of all sizes may be adapted to the surgeon's use, as suggested by Dr. J. T. Hodgen, of St. Louis, by simply breaking off the point and grinding the end in the form of a trocar: such needles, made quite short and handled by means of needle-holding forceps, may be used for almost any purpose for which curved needles are ordinarily employed. Wire or hair sutures about the eyelids seem to us superfluous.]

The eyelids and subjacent tissues may be the seat of malignant tumors of various kinds, among which the most common are epithelioma, and round-celled or spindle-celled sarcoma. Such growths threaten either great disfigurement or death, or both; and the preservation of an eye or of the eyelids becomes comparatively unimportant in the presence of such contingencies. If removal by the knife has once or twice been followed by recurrence, it will generally be desirable to empty the orbit entirely, and to aim at complete extirpation of the disease by the combined use of the actual and the potential cautery. This plan has been successfully followed by Mr. Lawson, in several instances of malignant orbital tumors in elderly persons; and in the seventh volume of the *Transactions of the Clinical Society* I have recorded a successful case in a child eleven years old, the subject of spindle-celled sarcoma, which first showed itself at the upper and inner angle of the left orbit, pushing the eyeball outwards and downwards. The growth was removed, as far as could be ascertained, entirely; but it returned in six weeks, and grew with great rapidity. An exploratory incision showed that it was passing back to the apex of the orbit, and infiltrating all the tissues. On the following day I removed the eyelids at the orbital margin, emptied the orbit as rapidly as possible with scissors, and dried up the cavity with the actual cautery. The ophthalmic artery was very troublesome, but its bleeding was at last arrested. The cavity was then closely lined with Fell's paste (℞. Zinci Chloridi, gr. 480; Farinæ, gr. 120; Liq. Opii Sed., f℥j), spread upon small pieces of lint, and was filled with cotton-wool to keep the lint in place. Morphia was injected subcutaneously while the patient was still under chloroform, and she slept for several hours, and awoke to little or

no pain. The shock of the operation was severe, and the child was very ill for a few days. The bones of the orbit exfoliated, and eventually she made an excellent recovery, although with an unsightly cavity in lieu of an eye. Three years have now elapsed, and there has been no appearance of a return of the disease.

The only tumors peculiar to the eyelid are those which arise from obstruction of the orifices or ducts of some of its numerous glands. Obstruction of the orifice of a sudoriparous gland occasions a small pearly or pellucid vesicle, generally situated on the cutaneous surface, very near the tarsal margin, and which collapses when punctured, giving exit to a drop of transparent fluid. Obstruction of the orifice of a Meibomian gland occasions a white spot, sometimes slightly elevated, on the tarsal margin itself; and the accumulated secretion may sometimes be seen as a white line on the inner surface of the tarsal cartilage, from which it may project sufficiently to become a source of irritation. Obstruction of a Meibomian gland at a point above the orifice usually occasions distension of the secreting follicles themselves, and issues in the formation of a small hemispherical tumor somewhere about the size of a split pea, fixed in the tarsal cartilage, and projecting externally. The skin is freely movable over such a tumor, and is unchanged in appearance; but when the lid is everted the base of the tumor appears as a thinned and discolored spot on the cartilage. If left alone, the tumor will eventually suppurate, and will discharge itself through the cartilage and conjunctiva [sometimes, though rarely, through the skin], often leaving a button of granulation projecting from the orifice by which the pus has escaped. This button may for a time be a source of direct irritation to the eye, but it will ultimately disappear. The tumors are harmless, but inconvenient and unsightly; and they may be got rid of by a simple incision through the thinned cartilage. If this gives exit to pus, nothing more need be done; but if inflammation has not taken place the tumor will be found to contain a semi-transparent gelatinous matter, and is then lined by a secreting membrane. It is necessary under such circumstances to empty out the contents by means of a scoop, and to tear and lacerate the lining membrane by scratching it in all directions with a cataract needle, or some similar instrument, in order to excite sufficient inflammation to destroy its secreting property. When this is done, the little cavity will at the time become filled with blood, and then, in the course of a few weeks, the swelling will dwindle and disappear. Should it not do so, it should be punctured again, and its lining membrane scarified more effectually than on the first occasion. In any case, a patient who has once had such a tumor will be liable to others of the same kind; because, as in the analogous case of sebaceous cysts, there seems to be a special proclivity on the part of some individuals to obstruction of the ducts or orifices of glands.

The tarsal margins are also the seat of small boils, commonly known as styes, which do not differ essentially from boils else-

where. They are most frequently met with in delicate girls, and are probably always due to some defect of the general health. A stye may occur in either the upper or the lower lid, and it commences as an angry pimple, which in the course of a few days passes through the ordinary stages of suppuration, discharge, and healing. It is, of course, painful, and it causes a good deal of temporary disfigurement; the attendant swelling being often sufficient to close the eye for a day or two. But its chief importance depends upon the liability of the hair-follicles to be destroyed by the contiguous inflammation, or even involved in the slough; so that a stye may leave a permanent gap in the row of eyelashes. Such a gap may be a serious blemish; and as styes, like boils elsewhere, are frequently recurrent, it is important, especially in the case of young ladies, to prevent them from running their course. It will almost always be found that a patient liable to styes requires constitutional treatment, and suffers either from anæmia or other obvious disorder, to which attention should be forthwith directed. Such patients are not unfrequently the subjects of habitual constipation; and it is worthy of inquiry whether the long retention of fecal matters may not be a source of unsuspected blood-poisoning. At any rate, all accumulated excreta should be removed by appropriate means; and, while any other necessary treatment is being pursued, the development of boils should be prevented in the following way. As soon as the first stage of the coming stye is perceived, the pimple being attended with a peculiar stinging sensation which the patient can at once recognize, the eyelash passing through it should be extracted by means of proper forceps, and a very fine point of diluted nitrate of silver should be immediately placed upon the mouth of the open follicle, and pressed there for a few seconds. [The diluted nitrate of silver stick is not easily sharpened to a fine point; a convenient way to make the application is upon a fine probe of silver or platinum, the end of which has been dipped in the mixed nitrates previously fused in a small silver or platinum spoon] The caustic should not be rubbed about indefinitely, but should be held steadily on the opening from which the hair has come, so that it may penetrate to the tissues below. If this is carefully done, the little surface eschar will not be larger than a pin's head; and the further development of the stye will be prevented. The application will produce temporary smarting; but nothing to be compared to the pain of the boil The cauterization, in order to be effectual, must be practiced early; for if too long delayed it will be altogether inoperative. For this reason it is generally best to give full instructions to some intelligent person living in the same house with the patient, so that no time may be lost when once the character of the pimple is recognized. A surgeon may sometimes chance to visit a patient when a stye is just beginning to form, and when a sufficiently fine stick of diluted nitrate is not at hand. Dr. Marcet has made known a substitute which is to be obtained everywhere, namely, the actual cautery, in the form of a glowing match. The

mode of application is to take a common match, light it, allow the composition to exhaust itself and the wood to be fairly kindled, and then break off the burnt portion, so as to leave a glowing point on that which remains in the hand. This glowing point pressed down and quenched upon the apex of any incipient boil, will at once arrest its progress. In order to apply it to a stye, without risk of injury to the eyeball if the patient should start, it is well to place some imperfect conductor of heat under the margin of the lid. A small paper-knife, or any other strip of bone, shell, or ivory, will be found well adapted for this purpose.

Perhaps the most important of the diseases proper to the eyelids, fortunately as rare in private practice as it is common among hospital patients in towns, is one which has received a great variety of names in its different stages. It has been called tinea tarsi, ophthalmia tarsi, lippitudo, and I know not what besides. I hold the multiplication of technicalities to be an unmixed evil; and I cannot see any advantage in the use of Greek words when English ones will do as well. But in this case we have a Greek word which is very useful, because it may be employed instead of an English phrase; and I am therefore accustomed to call the malady in question "Blepharitis,"[1] instead of describing it as "follicular inflammation of the eyelids." Blepharitis is very prevalent among the children of poor and dirty neighborhoods, especially in great cities; and its prevalence bears, I think, a distinct relation to the degree of atmospheric and personal dirt in any particular locality. At St. George's Hospital it is sufficiently common, and comes chiefly from certain districts; but at the Royal South London Ophthalmic Hospital, which is situated in a poor and crowded part of Southwark, the proportion of cases is far larger than at Hyde Park Corner. The disease consists essentially of an ulcerative inflammation, affecting the lining of the hair-follicles of the eyelashes. It is usually very limited at first; but if neglected or maltreated it soon spreads along the margins of the lids, and ultimately implicates contiguous structures. It usually commences in the upper lid, near its middle portion; and first shows itself by the formation of a scab or crust, which cements together the bases of three or four eyelashes. On close examination it will be seen that the margin of the eyelid, at the point corresponding to the scab, is somewhat swollen, and that the swelling extends about a line or a line and a half up the lid. The skin covering the swelling is not reddened, or directly implicated, but is perhaps a little smooth and glossy from tension. The size of the swelling is generally about equal to that of the scab; and the whole matter looks very trivial and unimportant. If we carefully soften the scab and remove it, and then examine the margin of the lid with a magnifying-glass, we shall find that the eyelashes of the affected part are not closely surrounded by skin, but that they project from gaping orifices, which yield also a small quantity of clear discharge. This, min-

[1] [This disease is commonly called *blepharitis marginalis*.]

gling with the greasy secretion of the contiguous Meibomian glands, and with that of the sebaceous glands of the hair-follicles themselves, dries into the crust characteristic of the malady. The inflammation seems to commence at the opening of a follicle, and gradually to creep down to the bottom of it, rendering the follicle patulous as it proceeds, and at last detaching the eyelash, which would fall out if it were not cemented to the margin of the lid and to its fellows by the scab. The secretion is probably contagious, and at all events is actively irritating, so that the disease spreads right and left along the eyelid first affected, and soon appears in the lower lid also. At first limited to one eye, it is before long conveyed to the other, probably by friction with dirty hands or foul handkerchiefs. After a time the swelling of the margin of the lids removes the lacrymal puncta from contact with the eyeball, and the tears are no longer carried away as fast as they are secreted, but remain lodged within the conjunctival sac, where they serve to retain also some of the secretion of the inflamed follicles. The consequent irritation produces inflammation of the conjunctiva, generally followed by inflammation of the cornea, and by the development of vessels under its epithelium. The inflammatory products which form the marginal swelling of the lids undergo gradual contraction; and, as they shrink, they curve and evert the tarsal cartilages. At the same time the persistent follicular inflammation destroys the eyelashes, or leaves them weak, scanty, distorted, and useless. The edges of the lids are red, bare, everted, and unsightly; the tears lodge in the eyes until they overflow, the conjunctiva is vascular, and the cornea is clouded by active inflammation or by residual opacity. Such are the results of neglected blepharitis; and they are to be seen only too frequently.

In its early stages, prior to actual functional destruction of the hair-follicles, and prior to distortion of the eyelids by the shrinkage of inflammatory effusion, the malady is very amenable to treatment, and this treatment may be of the simplest kind. It is only necessary to lay bare the seat of the disease by the complete removal of the crusts, to remove dead eyelashes, and to apply astringents to the ulcerated follicles with sufficient perseverance. The success of the treatment will depend almost entirely upon its continuance. A very short time suffices to improve the condition of the margins of the lids and of the orifices of the hair-follicles. Then, if the case, being better, is neglected, the inflammation creeps out again from the deeper parts of the follicles, where it was never cured at all; and a few weeks restores the original condition. In hospital practice we see this happen again and again, parents being unable or unwilling to devote the necessary time to the eyelids when the children seem to them to be better.

It is manifest that the complete daily removal of the crusts is absolutely essential to the cure. When Sydney Smith saw a little girl patting the shell of a tortoise in order to please the animal, he told her that she might as well pat the dome of St. Paul's to please

the Dean and Chapter; and to apply remedies to the outside of the crusts of blepharitis would be at least equally futile. These crusts, as I have said, contain a considerable greasy element, which enables them to resist the action of water; and if they are pulled off when only partially softened the parts beneath are excoriated and made to bleed. Worse still, the patient is hurt: and thus, if a child, is frightened and rendered intractable; a result which cannot be too sedulously avoided. The best way of removing the crusts is by a warm alkaline lotion; and about five grains of bicarbonate of soda to an ounce of water will be found a useful formula. I am accustomed to prescribe a lotion of twice this strength, and to direct that a little of it shall be poured out for use, and diluted with an equal quantity of hot soft water. If the patients can only command hard water, a little more soda will be necessary. The warm lotion is best applied by means of a morsel of sponge; and the edges of the eyelids should be soaked with it until every particle of crust is softened and can be removed. When this has been accomplished, the lids should be dried by pressure with a handkerchief, the lashes gently pulled, so that all that are loose may be plucked out instead of remaining as irritating foreign bodies within their follicles, and the selected astringent applied immediately, before the follicles are again sealed by the drying up of viscid discharges. If, after simple cleansing, the lids are examined at the end of half an hour, the inflamed part will be found covered by a thin transparent film of dried secretion, much resembling a layer of contractile collodion, and in like manner fastening itself down by indenting the tumid skin with little claw-like processes. Such a film forms quickly, and is scarcely visible unless carefully looked for; but it would shield the follicles from the action of a remedy as effectually as the accumulation of weeks.

The astringent selected is not a matter of great importance; but for home application it is best to prescribe an ointment. This ointment, whatever its active ingredient, should be quite soft, so that it may be easily worked into the roots of the eyelashes with the point of a camel's-hair brush. If it be too hard for this purpose, and almost always in cold weather, it should be softened by warmth before it is applied. I often recommend this to be done by dipping a teaspoon into hot water, drying it, and then using the point of the bowl to take out a morsel of ointment, which will at once liquefy, and may be taken up on the brush and applied before it becomes hard.

The ointment that I chiefly use in these cases is known to ophthalmic surgeons as Pagenstecher's; having been introduced into practice by Dr. Pagenstecher, of Wiesbaden. Its active ingredient is the precipitated yellow oxide of mercury, as thrown down by an alkali from a solution of the perchloride. This oxide, being an impalpable powder, is not a mechanical irritant, and it may be added to simple ointment in quantity varying from ten to thirty grains to the ounce. An alternative application is the ointment of the red oxide of mercury; and to either of the foregoing we

may add balsam of Peru in the proportion of about a drachm to the ounce. [Diluted nitrate of mercury ointment, white precipitate ointment diluted or of officinal strength, a mixture of white precipitate ointment with ointment of oxide of zinc and rose-water ointment, and white precipitate ointment mixed with one-fourth its weight of tar, are all useful, and any one of them may be prescribed instead of, or in alternation with, either of the ointments of oxide of mercury.] After a few days' use of either of these ointments, applied once daily, if there be no improvement, the first course to be pursued will be for the surgeon to undertake the treatment personally, by removing the crusts and applying the ointment himself. Cases reputed to be obstinate are usually those in which the people at home are careless or awkward; and such are to be met only in this way. Sometimes, however, blepharitis will resist mild astringents; and then it requires the application of nitrate of silver, which is best used in the form of a fused stick, diluted with nitrate of potash. Such sticks are made of various strengths, containing from one to four parts of the diluent to one part of the caustic. For blepharitis it is usually well to use the weakest. The stick should be filed or scraped to a fine point, which should be applied accurately to the tarsal margin immediately after the removal of the crusts. As soon as improvement is fairly established, the nitrate of silver may be laid aside for some of the milder remedies previously described; and after a time the intervals between the applications may be increased to two, three, four, or more days. [As substitutes for the mitigated nitrate of silver, or alternating with it, we may use *liquor potassæ*, tincture of iodine, liquefied chloride of zinc, liquefied chromic acid, nitric acid strong or dilute, or *liquor hydrargyri nitratis;* any of these may be applied upon a sharpened stick, or upon the tip of a probe wound with a little cotton, and should be washed off with a camel's-hair brush dipped in water.] But treatment must not be finally abandoned until the apparent cure has been tested by observation during at least a month; for otherwise there will be much risk of the reappearance of the malady. In some cases, when the cure is otherwise complete, there still remains some thickening of the tarsal margins, due to infiltration of the tissues with inflammatory effusion. Such thickening not only interferes with local nutrition by the compression of nerves and bloodvessels, but it also entails a liability to distortion of the lids by shrinkage; so that an endeavor should always be made to promote its removal. For this purpose the skin over the swelling may be painted with tincture of iodine, applied sufficiently often to maintain increased vascular action, but not in such a way as to produce any troublesome degree of soreness.

When a case of blepharitis does not come under notice until it is of some standing, the treatment will often be more difficult. We shall generally find that the lower lacrymal puncta are removed from contact with the eyeball, and that the retained tears form a source of perpetual irritation. We have then to consider whether

the puncta are displaced by contraction of the tissues external to the tarsal cartilages, or only by thickening of the lids by swelling. In the latter case it may be hoped that the treatment already described will diminish the swelling, and that the puncta will in time return to their normal position, and to the exercise of their proper functions. If, however, they are displaced by shrinkage, such a result is not to be hoped for; and the first step towards obtaining improvement must be to slit up the canaliculi, so that the tears may again obtain access to their proper channels of escape, and may cease to be sources of irritation to the patient. There are at least the two ordinary ways of performing this little operation,—the right way and the wrong; but concerning these I shall have to speak hereafter, when considering the treatment of diseases of the tear-passages generally.

Even in the worst cases of chronic blepharitis, when the tarsal margins are everted, red, and unsightly, the eyelashes destroyed, and the eyes suffering from irritation and exposure, the slitting of the canaliculi, and the use of some of the ointments mentioned above, will often improve the appearance and increase the comfort of the patient. No case of the kind, however unpromising, should be left without some endeavor to alleviate at least the most prominent symptoms.

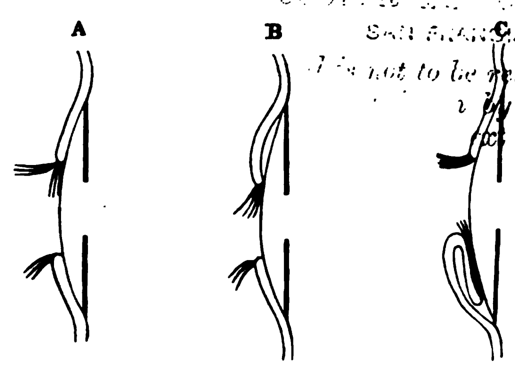
I have been content to speak of blepharitis as follicular inflammation of the eyelids, and to aim at curing it in that empirical fashion which has hitherto answered best in my hands. It is interesting, however, to inquire why it is that these particular follicles should become the seat of this obstinate inflammation. It has been suggested that blepharitis, as one of its names implies, is akin to tinea tonsurans; and it is now believed that tinea tonsurans is caused by the presence of a microscopic fungus, which has its habitat in the roots and shafts of the hairs, and which has been called *tricophyton tonsurans*. I presume it cannot be questioned that the hairs from a ringworm patch are infested by a minute fungus; but whether this is the cause of the disease, or is a consequence of it, or is only an associated phenomenon, I cannot pretend to determine. Dr. Tilbury Fox, however, announced, some years ago, that he had found the mycelium and spores of this particular fungus in the eyelashes in cases of tinea tarsi. My attention has only lately been called to this statement; and I have submitted eyelashes from many patients to microscopic examination. Dr. Tilbury Fox's method is to soak the suspected hair for twenty-four hours in diluted liquor potassæ, and then to place it in glycerine. But the liquor potassæ, which is intended to render the hair transparent, so modifies its external layer of cells that their margins present a very deceptive resemblance to mycelium threads; and, more than this, it sometimes causes these cells to peel of, and to form little masses against the side of the hair, which resemble mycelium still more strongly. When these sources of error are set aside, I fancy that genuine fungus will not be found in the majority of cases, perhaps not more frequently than upon hairs which are presumably healthy; and I

am not at all prepared to say what significance should be attached to its presence. Certainly I see no reason to admit that it can be an active cause of a malady with which it seems to be only occasionally associated; and, as the remedies already described are themselves parasiticides, I see no reason why the presence of fungus should modify the treatment to be pursued. Possibly, in any instance in which the hairs were much infested, it would be good policy to pull them all out beyond the limits of the disease.

The growing-in of eyelashes upon the globe of the eye, so that instead being protectors of the organ they are converted into sources of perpetual irritation, is a phenomenon met with under three perfectly different conditions. In many text-books we find a distinction between "trichiasis," a state in which the eyelashes are simply incurved, and "distichiasis," in which it is assumed that there is a double row, the outer of normal growth and position, the inner directed towards the eye. I have never seen what could be properly described as distichiasis, but I have frequently seen some hypertrophy of the tarsal margin, attended by the growth of cilia in abnormal numbers, some of them being misdirected. This kind of hypertrophy most frequently affects the external third of the upper lid; and probably often originates in the increased vascular action due to a slight attack of blepharitis in earlier life. [The occurrence of a partial supernumerary row of eyelashes, fairly justifying the name "distichiasis," is not excessively rare; we have seen at least one such case, doubtless congenital, in which the second row of cilia was very regular, and extended, in each eye, from the outer canthus for about half an inch along the margin of the upper lid near the row of openings of the Meibomian glands.] The second condition met with is one of incurvation of the tarsal cartilage, by which the position and the direction of its free margin are altered; and this change generally affects the whole length of the upper lid, and is a consequence of chronic conjunctivitis. Precisely as the lower tarsal cartilages are liable to be everted in blepharitis, by the shrinkage of inflammatory effusion external to them, so, in the same way, the upper cartilages are liable to be incurved by the shrinkage of effusions internal to them, or in the membrane by which they are lined. Such shrinkage occurs chiefly in persons in whom conjunctivitis has given rise to the formation of papillary granulations in the palpebral folds, and therefore, as will hereafter be shown, chiefly in the lower orders of Irish and in persons who have been in schools or regiments in which contagious ophthalmia has prevailed. The upper lids, in such cases, will be found unduly convex from above downwards, and, when they are everted, the cartilages will be found shortened and concave in the same direction, and marked by glistening bands or patches of cicatricial tissue. The displacement of the cilia is then a mere mechanical result of the alteration in the shape of the cartilage. [The cicatricial changes which lead to incurvation of the tarsus are mainly the result of a chronic pathological process involving the substance of the cartilage; in other

words, of inveterate "follicular granulations" (trachoma) rather than of the uncomplicated papillary form. The whole tarsus becomes misshapen, and the free border of the lid, which is normally about a line in width, loses its posterior angle and assumes the appearance of a mucous surface up to the line of implantation of the cilia. These also become more or less distorted and irregular in their growth, so that many of them come to rub upon the eyeball, while the Meibomian glands become partially atrophied, and their ducts, which normally appear as a row of minute openings upon the free border of the lid, acquire a faulty direction and open backward upon its conjunctival surface.] The third condition is one of displacement of the cartilage as a whole by perverted muscular action. This, which is usually called entropium, occurs most frequently in the lower lid, and is a common source of trouble after operations upon the eye in aged persons of lax fibre. It may exist in various degrees, but the spasmodic action of the orbicularis often cants the inferior cartilage quite over, turning its lower edge upwards, and bringing the lashes and the cutaneous surface of the lid to rest against the eyeball. We have therefore to recognize three conditions, which may be illustrated by the annexed diagrams. In the first, as at A, Fig. 56, there is

FIG. 56.



an excessive [and perverted] growth of cilia, the cartilage maintaining its normal relations with the globe. In the second, as at B, there is no excessive growth, indeed there is more frequently diminished growth; but the cilia (either upper or lower) are turned inwards by distortion of the lid. In the third, as at C, there is neither altered growth nor distortion, but the lower lid is displaced by disordered muscular action.

In each of these cases the surgeon must address himself to the cause of the evil. When the cilia are redundant, it may be sufficient for a time to remove them by epilation whenever they touch the eyeball, and it will occasionally happen that atrophy of the follicles will be thus produced. Epilation, simple as it seems, requires not only some care, but also the use of forceps with opposing surfaces which are so well fitted, and just so much roughened,

that they will hold the finest hairs. Such are sold under the name of cilia forceps by all instrument makers. They should be made to seize each hair singly near its root, and to extract it by a gentle steady pull. A jerking movement is apt to break the hair, and badly made forceps will cut it, in either case leaving a stump which may be difficult to extract, and which is far more irritating than a perfect eyelash. In cases of incurved lids the offending lashes are often very fine and pale-colored, and it is desirable to let the light fall upon the margin of the lid from different directions, and to use a magnifier, in order to see that none escape detection. Although epilation, in the case of mere redundancy, sometimes leads to cure, it is more common for the cilia to grow again and again, and in this case the continual plucking out may occasion

FIG. 57.

irritation and swelling of the lid. It is then desirable to abandon the practice, and to destroy the bulbs from which the ingrowing hairs proceed. If they are only two or three in number, this may be done by the actual cautery, for which Mr. Wordsworth's needle [see Fig. 55, page 174], or a common sewing needle fixed in a handle and heated in the flame of a spirit-lamp, furnishes the most convenient instrument. In order to use the cautery, it is generally advisable to administer an anæsthetic and to secure the lid by Snellen's forceps, shown in Fig. 57,[1] not on account of the pain, but because a slight movement of the patient at the moment of contact with the hot needle might baffle the operator, and cause him to make a puncture in the wrong place. The needle should be at a dull-red heat, should be introduced into the follicle from which each misdirected eyelash proceeds, and should penetrate about a line. If more than two or three cilia are in fault, the contraction that would follow burning would forbid recourse to it; and then there are two other methods, either of which may be employed. The hair-bulbs may be excised, or they may be destroyed by the action of a silk thread used as a seton; and the former plan is generally

[1] [Fig. 57 does not correctly represent Snellen's eyelid clamp or "forceps," but is based upon a modification of Snellen's clamp by Mr. J. Z. Laurence. Snellen's clamp is correctly shown in Fig. 59.]

to be preferred, because it is more under control than the latter. The seton may chance to destroy all the cilia between its points of entrance and exit; whereas the object of the surgeon is to destroy only those which are misdirected.

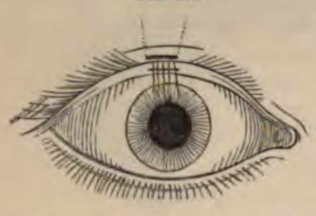
[FIG. 58.]

[Perhaps the neatest and most accurate way of cauterizing a single hair-follicle is by passing a very fine platinum wire through it in close proximity to the eyelash, bringing the end out through the skin near the margin of the lid, and then heating the wire momentarily to redness by passing through it the current from a single cell of a Grove or Bunsen battery. The wire may be of a diameter of about $\frac{1}{200}$th of an inch, and may be easily drawn through the follicle by a fine thread, previously passed by the aid of a very fine curved needle. After the wire is in place, and any bleeding has entirely ceased, the free ends of the wire, at the margin of the lid and at the point of emergence through the skin, are seized by two pairs of forceps, connected by wires with the two battery poles. The platinum wire becomes heated almost immediately, and a second generally suffices to complete the cauterization.]

In order to excise a group of superfluous bulbs, it is desirable to inclose the lid within Snellen's forceps, and to screw the blades so closely together that there may be no bleeding to obscure the view of the operator. A fine scalpel or a Beer's knife should then be thrust into the margin of the lid, parallel with the plane of the cartilage, and just under the skin, in such a way that the blade separates any normally directed cilia, which it may be desirable

to preserve, from the abnormally directed, which are to be sacrificed. The point of the knife should be carried well above the roots of the cilia, and moved towards the cutting edge in such a way that the wound may be as broad above as below. A second thrust should then be made, parallel to the first and of equal extent, close to the conjunctival margin of the lid, and separated from it only by the orifices of the Meibomian glands; and the parallel incisions should be long enough to include between them all the cilia which are to be destroyed. The operator then places one blade of a fine pair of scissors in each incision, and, by two snips, cuts out the intervening piece of cartilage subcutaneously, together with any hair-bulbs which it may contain. A moist cold compress should be applied for a few hours, after which no further dressing will be needed; and if any misplaced eyelash has escaped, it may be destroyed with a hot needle on a future occasion. The diagram in Fig. 59 shows the position of the two incisions, with reference to the cilia, the margin of the eyelid, and the orifices of the Meibomian glands, and the dotted lines show the extent and depth of the incisions in the lid.

FIG. 59.



[Operations in which a small group of eyelashes is excised are not altogether satisfactory as regards the permanence of the cure. A few months after an apparently perfect operation a few cilia will often be found growing in a faulty position, and will require to be pulled out or treated by some more radical method. The operation of excision, as described and figured by the author, is one which we have long employed, and it is probably as effective as any with which we are acquainted.]

The use of the suture was first suggested by Dr. Herzenstein,

FIG. 60.

whose illustrative diagram is reproduced in Fig. 60, from the *Archiv für Ophthalmologie.* The eyeball is protected from injury

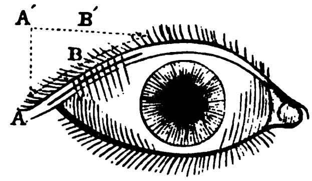
by the spatula, and the needle, armed at the point with a double silk thread, is introduced on the margin of the eyelid at the point *a*, on one side of the group of hairs to be destroyed, is carried vertically upwards, and made to emerge on the skin at *b*, about two lines above its entrance. It is reintroduced at the second puncture *b*, carried horizontally for a sufficient distance to clear the other extremity of the group of hairs, and is again brought out at *c*. Reintroduced at this third puncture, it is carried vertically downwards, and made to emerge on the tarsal margin at *d*, where the silk is seized and retained, and the needle finally withdrawn. The two ends of the silk are then knotted together, and a subcutaneous loop is formed, which includes the bulbs of the misdirected hairs, and soon destroys them by the inflammation which it excites. When free suppuration commences, the thread may be cut and removed.

The cases of incurvation of the superior cartilages are more numerous than the foregoing, and, thanks to the late unchecked prevalence of contagious ophthalmia in pauper schools, they are likely to present themselves in still greater numbers in years to come. They have much exercised the ingenuity of surgeons, and many operations have been devised for the relief of the sufferers. One of these, which I mention only in order to condemn it, was usually called "scalping." It consisted of the absolute removal of the hair bearing margin of the lid; and afforded a temporary relief, which was usually dearly purchased by the injury soon inflicted upon the eye through the loss of its accustomed protection. Although revived as a surgical proceeding in comparatively recent times, the operation is not of modern invention, since history tells us that it was among the tortures by which the Carthaginians vainly endeavored to shake the fortitude of Regulus. Among the occasional out-patients of St. George's Hospital there are two unfortunate women, to whom I have before made incidental reference, and whose hard lot it has been to be thus treated. In their cases, so much of each upper eyelid has been removed that the palpebral fissure cannot be closed, and the conjunctiva has undergone a dermoid degeneration which has produced almost total loss of sight, and which admits of no cure, although it may be ameliorated by the frequent application of glycerine. [Two very different operations are often confounded under the name "scalping." The obsolete and rude procedure mentioned in the text cannot be too strongly condemned, though still occasionally followed by charlatans. The other operation, that of Flarer, consists in the ablation of a narrow strip of tissue, including only the integument, muscle, and the hair-bulbs, leaving the tarsal margin intact; it involves, of course, the total loss of the eyelashes, but does not, as a rule, lead to contraction of the opening of the lids or other deformity.] Another plan, suggested by Dr. McCraik, of Smyrna, was to excise from within the lid a horizontal strip of the middle of the cartilage, leaving the skin and the upper

and lower portions of the cartilage intact, and removing only the crown of the arch of incurvation. I have performed this operation in several cases, and the immediate results were excellent. Unfortunately they were not permanent, and after the lapse of a few months the patients returned as bad as ever; a result which has frequently followed other devices for the cure of the affection. Of the plan of grooving the cartilage, suggested by Mr. Streatfeild and others, I have no experience; but for the last three years I have relied almost entirely upon an operation founded upon that of Jäsche and Arlt, but differing from it in some minor details. With this I have been well satisfied, not only as regards the immediate, but also as regards the permanent effects. In many cases the cure has been complete, and has remained so after the lapse of a year or more; and the patients for whom further treatment has been needed have seldom required more than the destruction, by knife or cautery, of one or two stray cilia. The operation is performed by splitting the tarsal cartilage into two layers, an anterior layer carrying the hair-bulbs, and a posterior containing the Meibomian glands. A horizontal strip of the anterior layer is then removed, together with the muscle and skin covering it; and the ciliary margin of the anterior layer is transplanted upwards, leaving the lower portion of the posterior layer exposed. When the whole length of the lid is implicated, a Beer's knife should be entered on the tarsal margin, near the lacrymal punctum, with its cutting edge directed towards the outer canthus. It should be carried pretty deeply into the substance of the cartilage, and then made to cut its way slowly along the lid, splitting the cartilage as it goes, nearly as far as the canthus. Great care should be taken to leave no hair-bulbs in the posterior layer. The knife should penetrate nearly to the upper margin of the cartilage; but, if this is much incurved, the necessary depth must be attained by two or three successive incisions, in order to avoid perforation of either layer. When the splitting is completed, an incision must be made along the whole length of the lid, about a line above its margin, through the skin, the muscle, and the anterior layer of the split cartilage, and another incision in the same direction and through the same structures, but higher on the lid and joining the preceding one at its extremities These two incisions will include an elliptical portion, which must be detached and removed; and the strip of margin, left below the first incision and attached only at its extremities, must be carried up and united by sutures to the edge of the wound above. When, as sometimes happens, only the outer half of the lid is implicated, the splitting of the cartilage may be commenced near the middle of the lid, but so as to include the whole of the distorted portion. It must then be carried quite to the outer canthus, from whence a vertical incision must be made upwards. The piece excised should be triangular, its base formed by the vertical incision, and its apex being over the point at which the splitting com-

menced, as indicated diagrammatically in Fig. 61, where the dark line shows the course of the knife in the cartilage, and the dotted lines show the subsequent incisions, which may be most conveniently made with scissors. The portion of the lid containing the cilia (which is attached only at one extremity) is carried up from A and secured by suture at the point A′; and it is usually advisable to insert a second suture midway in its length, as at BB′.

FIG. 61.



I seldom apply any dressing, but leave the blood to dry upon the incision and upon the exposed surface of the posterior layer of cartilage. The latter soon shrinks so as to occasion no deformity, and, if the extent of transplantation has been sufficient, it is very rare for the cilia again to reach the surface of the globe.

[The operation described by the author, differs from that of Jäsche Arlt chiefly in the splitting of the lid, which, in Arlt's practice, is always done in front of the tarsal cartilage, and not in its substance: in removing the elliptical piece of skin from the upper lid, Arlt especially directs that the fibres of the orbicularis muscle are to be spared, and he abstains also from unnecessarily detaching the narrow bridge of tissue containing the bulbs of the eyelashes, for fear of fatally impairing its vitality. (See Arlt, *Graefe und Saemisch*, *Handbuch*, III, page 448.)

In trichiasis or entropium of the upper lid with incurvation of the tarsus, no operation is fully satisfactory which does not correct this acquired malformation, so far, at least, as regards the improvement of the form and direction of the margin of the lid. To effect this it is necessary to turn the whole margin of the lid forward in such a way as to restore the cilia to their normal direction; we cannot, as a rule, bend the deformed and thickened cartilage by any force we can apply to it, but it is generally quite practicable to turn the whole edge of the lid forward after having deeply incised or cut through the thickened tarsus, in a line parallel to and two or three millimetres distant from its free border. The operation of grooving the tarsal cartilage, has been worked out by Streatfeild and Snellen. Both surgeons first excise a strip of skin and muscle about a line in width, and about the same distance back from the palpebral margin, and then carefully cut a deep longitudinal furrow in the exposed tarsal cartilage. Streatfeild leaves the wound to heal by cicatrization, while Snellen prefers to apply several deep sutures in the cartilage; in either case the result is the rectification of the position of the whole margin of the lid including the cilia implanted in it. An older operative procedure, which has been from time to time revived with various modifications, is to incise the eyelid throughout its entire thickness, parallel to and about a line back from its free border, and from one end of the lid to the other; the incision may be made either from the conjunctival or the cutaneous surface of the lid,

and it may be made either wholly with a knife, or in part by scissors. A narrow strip of skin and muscle is then removed, and the separated margin of the lid is turned forward, and held in position by carefully applied sutures. If the opening of the lids has been much shortened by the disease, a canthoplastic operation should be combined with the operation upon the tarsus, whether it be by grooving or by incision.

In many trials, both of Arlt's operation, and of Von Graefe's modification of the same, we have failed in the majority of cases, to attain permanently good results. We have also found it very difficult to groove the tarsal cartilage deeply enough to permit the free margin of the lid to be easily bent into the desired position. We prefer, therefore, to make a bold longitudinal incision through the conjunctiva and tarsus, from one end of the tarsus to the other, and parallel to and about a line or a line and a quarter distant from the free border of the lid. We then excise a strip of skin a little more than a line in width, and about a line distant from the row of eyelashes, and turn forward the loosened margin of the lid, and secure it in its new position by from three to five sutures. The needle carrying the suture, is made to enter at the edge of the lid, in or near the row of cilia, and is carried upward just beneath the skin, until it appears in the cutaneous wound; it is then plunged deeply through and behind the fibres of the orbicularis muscle, and is brought out through the skin from a third to a half of an inch above the upper lip of the wound. The effect of the row of sutures applied in this way, is to tilt forward the margin of the lid, with the implanted cilia, leaving the longitudinal wound on the conjunctival surface to heal by granulation. When the tarsal cartilage has been very much thickened, we have removed a wedgelike strip from the upper portion before proceeding to the excision of the strip of skin. This operation is essentially the *tarsotomia horizontalis* of Von Ammon as modified by Roser. (See Ruete, *Lehrbuch der Ophthalmologie*, II, page 205.) The chief, and we believe important point of difference being that we do not cut through the whole thickness of the lid, but confine the principal incision to the conjunctiva and tarsal cartilage, and in the excision of the narrow strip of skin we are careful to spare the underlying fibres of the orbicularis muscle]

The cases of the third class, in which the cartilage of the lower lid is turned over, are easily cured by the excision of a narrow horizontal strip of skin and muscle; a little operation which is most conveniently done by means of scissors. The first incision should be at a little distance down the lid; the second, meeting the first at both extremities, should be close to the roots of the eyelashes. It is desirable to make the lower incision first, in order that it may not be obscured by bleeding from the upper one. Some operators pinch up a fold, and cut it off at a single stroke of the scissors; but this plan is not to be commended. The resulting wound will be either too short or too wide; in the first case only

partially correcting the defect, in the second, everting the punctum and producing some degree of ectropium. It is necessary to be very careful not to remove too great a width of skin, and inexperienced operators are almost certain to err in the direction of doing too much. A single suture may be applied in the middle of the wound,[1] which will require no other dressing. The form of entropium under consideration, sometimes occurs in old people after operations upon the eye, being then the result of spasm of the orbicularis excited by irritation, and combined with general laxity of the non-muscular tissues. It is sometimes possible to overcome the spasm, and to keep the lid in its proper place, by painting the cheek with contractile collodion, or by the careful adaptation of strips of waterproof adhesive plaster. Both these methods, however, are liable to fail; and it is better to remove a strip of skin than to place undue trust in either of them. If the little operation is nicely done it will leave no visible cicatrix; and if the strip removed is not too wide, there will be no eventual alteration in the position of the tarsal margin.

Ectropium, or eversion of the lids, is produced in a slight degree, as already mentioned, by neglected blepharitis; and ectropium of the lower lid is not uncommon in old persons, as a result of hypertrophy of the conjunctiva following inflammation. The latter form may usually be cured by the free application of nitrate of silver to the exposed surface, the lid being restored to its place by the contraction which follows the separation of the eschar. Ectropium of the lower lid may also be consequent upon motor paralysis of the face, the lid tending to fall downwards by its own weight when no longer restrained and supported by the orbicularis. Both lids may be everted by the contraction of neighboring cicatrices, such as may follow burns, some kinds of skin disease, or the removal of necrosed bone. The conditions thus produced can only be cured by carefully planned and skilfully executed plastic operations, the details of which must differ in every case, and which it would be foreign to my purpose to describe. But threatened ectropium from cicatricial contraction may sometimes be prevented, if the case is seen in time, by the simple expedient of paring the edges of the lids, and uniting them by two or three points of suture. The eye will thus be kept closed until the period of contraction has passed, when the artificial union may be severed. Moreover, in all burns or other wounds about the face or temples, it is desirable to promote healing by skin-grafting, so that the tendency to contraction may be diminished as much as possible. If the ectropium is paralytic it hardly admits of treatment, except by faradization of the affected muscle, or by slitting the lacrymal canaliculus to afford the tears a passage into the sac; a course which is also indicated, as a general rule, in the form consecutive to blepharitis.

Symblepharon, or union of the eyelids with the globe, is a

[1] [The suture may generally be omitted altogether.]

traumatic affection which usually follows the destruction of the conjunctiva by lime or hot metal, and which occurs chiefly in the lower lid. The cases seen in London are nearly all produced by lime; but in the neighborhood of great metal works a splash of molten metal is a more common cause. Whatever may be the destructive agent, if the opposed surfaces of the globe and of the eyelid are both denuded, they will almost certainly become firmly united in healing, whatever pains may be taken to keep them apart. The union frequently extends over a large portion of the cornea, and is always a source of much irritation and distress, partly on account of the restraint imposed upon the movements of the affected eye. We are indebted to Mr. Teale, of Leeds, for a mode of treating symblepharon which has superseded all others. He completely divides the union between the lid and the globe, dissecting down the former until it is quite free, and then transplants a piece of the healthy ocular conjunctiva to fill the gap produced on the ocular surface. The size and shape of the transplanted piece, the direction from which it is taken, and the way in which it is brought into the gap, are points of detail which must be governed by the peculiarities of the case. The principle is that the raw surface of the eyelid has no corresponding raw surface to which it may adhere; and it is found in practice that the ocular conjunctiva, even if removed for transplantation from nearly the whole of the surface sheltered by the upper lid, will in a short time be reproduced so completely as to leave scarcely a trace of the operation. When a symblepharon is very extensive, the first division will often leave one or two cicatricial bands, which may require subsequent treatment of the same kind; but as a rule the free mobility of the eye may be at once restored, and the sensation of dragging relieved. Moreover, after the successful detachment of a symblepharon, the opacity of the cornea, being no longer fed by the vessels of the lid, usually disappears in course of time; and excellent vision is often thus restored to an eye which seemed, at first sight, to be almost entirely disorganized.

In paralysis of the orbicularis muscle, due to lesion of the portio dura, the eyelid can be closed only imperfectly; a condition chiefly seen in the lower lid, inasmuch as the weight of the upper lid counteracts, to some extent, the influence of the levator palpebræ. In paralysis of the third nerve, when the levator palpebræ is among the disabled muscles, the weight of the upper lid brings it down, and produces a passive closure of the eye which is known as ptosis, and which may be complete or incomplete according to the degree of the paralysis. In complete ptosis the lid hangs down without a wrinkle, and cannot be lifted by any effort of the will, although it may sometimes be slightly influenced by the action of the anterior fibres of the occipito-frontalis. In the incomplete forms there is only partial closure, and more or less control, according to circumstances. When ptosis is associated with paralysis of the other muscles supplied by the third nerve, that is to say, of the internal, superior, and inferior recti, the

inferior oblique, the sphincter pupillæ, and the muscle of accommodation, it indicates some disease of the trunk of the nerve, or some injury inflicted upon it; and such cases are often due to syphilitic thickening of the periosteum at the sphenoidal fissure. When the ptosis stands alone, it more probably indicates some disease or impairment of blood-supply of the nerve-centres in which the filaments going to the levator muscle have their origin. In either case ptosis must be treated in the first instance upon general principles; but after a time, if it appears to be established as a permanent condition, it may be relieved or cured by an operation for shortening the lid. An elliptical piece of skin and of the subjacent muscle must be removed, and the edges of the wound united by sutures. In some cases it is desirable to remove the muscle very freely, both above and below the limits of the cutaneous incision. The surgeon must not aim at restoring symmetry of the lids when the eyes are open; but must be content to lift the margin of the paralyzed lid sufficiently to uncover the pupil for visual purposes. If too much skin is removed, the lid will have a strained and tight appearance, and the power of closing it may be taken away, in which case the cornea will be likely to suffer from ulceration produced by exposure. If too little is removed, the pupil will still be covered, and the operation be wholly useless. It is not generally desirable to operate for ptosis when the other eye is sound, if any of the recti muscles are also paralyzed; because then the closed lid saves the patient from the still greater inconvenience of double vision; and in the rare cases in which ptosis is congenital an operation would generally be of very doubtful utility.

[Ptosis, like paralysis of the other orbital muscles, is often amenable to treatment by electricity. We have employed, for the most part, the constant current, applied as advised by Benedikt (*Archiv für Ophthalmologie*, X, I, pp. 97–122), and, as it has seemed to us, with very positive advantage in recent paralysis of the several recti muscles: it so happens that we have not had the opportunity of trying it in a recent case of ptosis.]

Besides passive closure from paralysis, we may have active closure of the lids from spasm, which is probably always of a reflex nature, induced by some impression upon a filament of the fifth nerve. We see such spasm assume a chronic character in photophobia, which is usually traceable to superficial inflammatory mischief in the cornea or conjunctiva; or it may appear as an irregularly remittent affection in cases in which its peripheral origin is not manifest.

The spasm of photophobia occurs chiefly in the young. There are many children, with some corneal affection, to whom light is painful, or at least irksome. They seem to have no power to open their eyes; and, when told to do so, usually open the mouth instead. From this slight degree we meet with every gradation up to a state in which the orbicular muscles are contracted with all possible force, with the features distorted to aid in the contraction; in

which the child will hide its face in the darkest corner of the room, in its hands, in pillows, in its mother's dress, excluding every gleam of light by every available protection. In such cases the eyelids are so closely shut that tears find no continuous outlet, but accumulate under the lids, and escape in hot gushes when they are raised. In its extreme forms, photophobia is chiefly seen in cases which have been either neglected, or aggravated by the improper use of caustic or irritant applications. When it is present, it becomes a question of degree whether we may cure the corneal affection, and so get rid of the spasm of the eyelids, or whether we must get rid of the spasm before the corneal affection can be cured. It is manifest that a high degree of spasm must be itself injurious. The pressure exercised upon the sore eyeball produces reflex muscular action by which that pressure is maintained; and the retention of irritating tears is not only injurious in itself, but serves to dilute and remove any local applications which may be employed. The muscular contraction maintains a high degree of venous congestion. In most cases, and especially if the patient can be seen daily, we may first try the effect of treatment upon the original malady. But if the treatment fails to afford speedy relief, or if the patient comes from a distance, or if the photophobia has been long continued and is severe, it will be well to cure the spasm in the first instance. A fair practical test of severity is afforded by the fact that two opposing surfaces of skin, when held in prolonged and close contact, assume somewhat the character of mucous membrane. In a case of aggravated spasm, when the orbicularis is rendered passive by chloroform, we find a little moist red chink, running horizontally outwards from the external canthus towards the margin of the orbit. The surfaces of skin have here been brought into contact by muscular action; and the change referred to has taken place in them. When this chink is well-marked, it will usually be necessary to cure the spasm before we can cure the eye.

The cure of the spasm is fortunately simple and easy. It is only necessary to render its continuance impossible for a time by complete division of the offending muscle. This is best done in the direction of the chink, by transfixing with a small bistoury from within outwards, and dividing conjunctiva, muscle, and skin, in a horizontal line, right up to the margin of the orbit. The loaded veins will empty themselves by free bleeding, which soon stops, and is probably highly salutary. The closed lids may then be covered with a compress dipped in cold water, and retained by a bandage; and the patient should be put to bed in a room from which all but dim candlelight is excluded. In twenty-four hours the cornea will have lost its irritability and may be submitted to treatment. In forty-eight hours the patient will usually be able to walk abroad in daylight without inconvenience. The incisions will heal without leaving any visible cicatrices; and the power of the muscle will eventually be completely restored.

[We prefer to operate, for spasm of the orbicularis, or for contraction of the opening of the eyelids, according to the method of

Dr. C. R. Agnew (*Canthoplasty as a Remedy in certain Diseases of the Eye*, New York, 1875). "The external commissure of the eyelids should be split to the bottom of the conjunctival cul de sac, through skin, orbicular muscle, canthal ligament, and conjunctiva. This is best done with a pair of strong, sharp scissors, that will cut to the point. The length of the cut will vary from a half to five-eighths of an inch, depending upon the depth of the cul de sac. Its direction should be accurately horizontal.

"The next step is for the operator to take the upper eyelid between his thumb and forefinger, and draw it a little in an upward direction and towards the nose, until he feels the external canthal ligament upon the stretch. When this is felt he should introduce the blades [points] of a medium-sized pair of scissors into the wound, and nick the stretched edge of said ligament in the vicinity of the orbital border. . . . There will be an appreciable yielding of the lid to the traction the moment that the edge of the ligament is nicked, a feeling that all will recognize who have ever divided a tense tendon."

The operation is completed by the introduction of three or four fine sutures, "so as to stitch the cut conjunctiva neatly to the cut skin all around the enlarged or new commissure, excluding from the sutures the cut ligament." In cases of simple spasm of the orbicularis, and of swelling of the conjunctiva from acute inflammation, it is often better to omit the sutures.]

The principle on which this treatment rests is well established in various branches of surgery. There are many conditions in which spasm of a sphincter muscle maintains or aggravates disease, and in which the division or dilatation of the sphincter is a necessary preliminary to other treatment. Dilatation is inapplicable to the orbicularis, and only division remains. We may admit that many cases of spasm of the eyelids, which are capable of being cured immediately by myotomy, might be cured without it in course of time. But in the treatment of eye disease rapidity of cure is a matter of primary importance, because the tissues of the eye are liable to be irreparably injured by the continuance of morbid processes, and because the use of the organ is essential to the discharge of many of the duties of life. The malady in question, moreover, involves great suffering; and the little operation recommended (which may be done under chloroform during the examination) is so speedy, certain, and harmless a remedy that, in any bad case, there should be very cogent reasons to justify neglect to employ it.

The remittent form of contraction of the orbicularis, to which the word "blepharospasm" is usually restricted, produces closure of the eyelids at uncertain times and of uncertain duration, but generally either excited or aggravated by external irritants or by mental anxiety. I can recall the case of a gentleman who was in the habit of driving, and whose eyes would every now and then shut up for two or three minutes, especially on a windy or dusty day, so that he would be compelled to stop his horses as his only

security against a collision. I have been consulted by a schoolmistress who suffered in a similar manner, and whose pupils took much advantage of her infirmity; and also by a cook, whose eyes would sometimes close at the critical period of a dish, and only reopen when it was hopelessly spoiled. In all such cases the first thing to do is to search for any source of local irritation (such as a carious tooth) or for any condition of the general health which may be productive of exaggerated nervous sensibility; and, if no special clue can be found, it is worth while to try the use of bromide of potassium, or of such tonics and anodynes as the circumstances of the case may suggest. If general treatment is not productive of benefit, the only remaining resource is to divide the afferent nerve by which the peripheral impression is conveyed to the centre. This nerve is usually either the supraorbital, or the subcutaneous malar; and may sometimes be identified by the fact that firm pressure upon it will relax the spasm. I cured the cook above mentioned by division of both her supraorbital nerves; and Von Graefe has recorded a case of cure by division of the subcutaneous malar. To perform the operation, it is only necessary to carry a tendon knife under the skin, directly across the track of the nerve, and then, turning its edge backwards, to divide everything lying between it and the bone.

The lacrymal gland and passages, although they do not, strictly speaking, form parts of the eyelids, are yet so closely connected with them that an account of their maladies may appropriately be included in the present chapter.

The anatomy of the lacrymal apparatus is simple. The gland, situated in a depression at the upper and outer angle of the orbit, pours its secretion into the conjunctival sac by fifteen or twenty ducts which have their orifices beneath the upper lid, and in the upper retrotarsal fold. The secretion, which consists of water with an almost inappreciable saline impregnation, flows over the conjunctiva, and passes to the inner canthus, where it enters the lacrymal puncta. In ordinary states the quantity is only so much that the puncta can convey it away without overflow; but it is increased by irritation of the ocular surface, or in some cases by emotion, and then the conjunctiva becomes overfilled, and the tears run down the cheeks. Each punctum leads into a delicate passage or canaliculus; and the canaliculi open, sometimes together, sometimes separately, into a small receptacle, the lacrymal sac. The sac is obscurely triangular in form, with its apex downwards, and this apex is continuous with the nasal duct, which passes through a channel in the lacrymal and superior maxillary bones and opens into the inferior meatus of the nose. [The lacrymal sac is about twelve millimetres long, contracted and closed above, and again somewhat contracted below, where it is continuous with the nasal duct, so that its middle portion is the widest. In cross section it is oval, having an antero-posterior diameter of five millimetres and a transverse diameter of four millimetres.—See Merkel, *op. cit.*, p. 97.] The lacrymal passages are lined through-

out with mucous membrane, which connects the conjunctiva with the Schneiderian surface generally.

The lacrymal gland itself is seldom diseased; insomuch that I have only met with a single instance. In this case the patient, a young lady of eleven years old, was brought to me with a tumor projecting from under the upper and outer angle of the right orbit, and pushing the eye downwards and inwards. Her father, himself a medical man, regarded the tumor as a cartilaginous outgrowth from the orbital periosteum; and the probability of this view was increased by the existence of cartilaginous outgrowths from the lobes of both ears, where they had been pierced.[1] The projecting part of the tumor was as large as a full-sized hazel-nut; it was painless, and presented that sort of obscure semi-mobility, and that degree of hardness, which might have been expected from cartilage. I advised its removal; and on dividing its investments we were surprised to find a comparatively soft tumor, the apparent hardness of which was due to the tension of a fibrous capsule. The growth was extensive, penetrating somewhat deeply into the orbit; but it was dissected out and entirely removed, and was found to be an indurated and hypertrophied lacrymal gland. The wound healed kindly, and the patient has since suffered no inconvenience; although there is still some thickening and drooping of the upper lid, and the right eye remains slightly lower than its fellow. It seems probable that the superior rectus muscle may have been injured by compression during the growth of the tumor.

Epiphora, or watery eye, is a term which should be limited, strictly speaking, to habitual hypersecretion of tears, unattended with obstruction of the passages of discharge, but filling or overflowing the conjunctival sac by mere redundancy The tears in such a case are not only sources of discomfort, but they interfere with vision by disturbing the refraction of light. The affection is generally monocular; and, in the few cases which I have seen, it has been due to hyperæmia or granulations lurking in the retrotarsal folds, and has been cured by treatment addressed to these conditions. It is of rare occurrence, and would scarcely require notice but for the circumstance that it may be erroneously attributed to obstruction. In one of my patients the inferior canaliculus had been slit up, and probes had been passed into the nose, of course without benefit, and although no obstruction had ever existed. [In the only case of uncomplicated epiphora which we have seen, the trouble existed in both eyes alike. The patient, a lady of about thirty years of age, had suffered for ten years from excessive flow of tears, which was wholly independent of any irritating cause or mental emotion. The flow was very abundant in the early morning, gradually diminishing during the day, and ceasing altogether by afternoon. Often for many days together no overflow of tears occurred, then, without appreciable cause, the trouble would return. Nothing abnormal was detected, except a

[1] [Tumors following the operation of piercing the lobule of the ear are generally fibromata.]

slight degree ($\frac{1}{60}$th) of hypermetropia, with apparently a little accommodative asthenopia.]

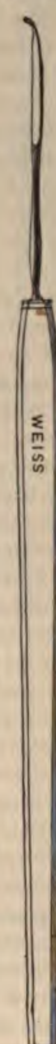
Obstruction of the lacrymal passages is very common, and may occur on either side of the sac. Occlusion of a single punctum, or of a single canaliculus, produces no more inconvenience than a diminution of the ordinary channels of exit, so that overflow is produced by a smaller quantity of secretion than that which the original capacity of these channels would have suffered to escape. Occlusion of both puncta, or of both canaliculi, is followed by overflow whenever the amount of secretion is at all in excess of the loss by evaporation into the atmosphere. Analogous conditions are produced by any swellings or deformities of the lids which remove the puncta from contact with the globe, with the addition that such swellings or deformities usually give rise to an interval between the lower lid and the eyeball, in which tears may accumulate, or to a broad base on which a wedge-shaped film of fluid may be supported against the cornea.

Obstruction of the nasal duct is a far more serious matter, because the tears pass unchecked into the sac, distend it, and in time produce irritation, and ultimately inflammation of its lining membrane; while, as soon as the sac and canaliculi are filled, an overflow of tears from the eye occurs as if the canaliculi were themselves occluded. In the first stage of such a case the patient complains only of the overflow. On examination, the surgeon finds a small globular swelling below the inner canthus, over the lacrymal bone; and by pressure on this swelling he causes fluid to escape into the eye through one or both puncta. The swelling is the distended sac, and its presence proves at once the patency of the passages leading from the eye to the sac, and the occlusion of the passage leading from the sac to the nose. The fluid which can be pressed out through the puncta is that which is contained in the sac, and it may consist of tears and mucus somewhat inspissated by absorption, of muco-pus, or of pus, according to the state of the lining membrane. Sooner or later, in all neglected cases, pus is formed, and the openings of the canaliculi into the sac become closed by internal swelling. When this occurs, the sac is converted into the cavity of an abscess, which runs the usual course, and ultimately discharges itself externally on the cheek, just below the tendo oculi. The opening thus formed is [often] permanent, and constitutes "fistula lacrymalis." When all inflammation has subsided, the fistula gives exit only to an occasional tear; but the membrane of the sac remains in a morbid and sensitive condition, ready to secrete pus in response to variations of health or to slight causes of local irritation.

The treatment of obstruction of the nasal duct, both before and after the formation of fistula, has occupied the thoughts and pens of many skilful surgeons and learned writers, especially of [Scarpa, Ware, Travers, Hays], Bowman, Weber, [E. Williams], and Stilling. The old method [of Scarpa and Ware] was to puncture the lacrymal sac from the cheek, to carry the knife through the

obstruction in the duct, and then to insert a gold, [silver or lead] style, which was worn permanently, and by the side of which fluids found their way from the sac into the nose. The lower extremity of the style rested on the floor of the nose, the upper extremity, fashioned into a knob or button, on the cheek just below the tendo oculi. [Mr. Travers treated obstructions of the nasal duct by probes or styles passed through the previously dilated upper or lower punctum, a method which Dr. Hays, of Philadelphia, carefully studied and improved.] As an improvement on this plan, Mr. Bowman devised the method of slitting up the canaliculus, so as to render the lacrymal sac [more freely] accessible from the corner of the eye, and of passing probes [of larger size] through the obstruction. Weber contrived, for slitting the canaliculus, the convenient knife which bears his name (shown in Fig. 62), and modified the shape and size of the probes. Stilling designed a knife [Fig. 63] intended for the division of the obstruction itself, which he treated, like a stricture of the urethra, by free internal incision. Others, of less distinction, have advocated various other expedients; but, after having read their writings with due care, after having given full and fair trial to all methods in favor of which a *primâ facie* case could be made out, and after having watched attentively the results of various kinds of practice, I have come to the conclusion that the best treatment, in a great number of instances, is that which is only palliative, and that the best surgery, generally speaking, is to leave the obstruction alone.

FIG. 62.



A stricture of the nasal duct resembles stricture of the urethra at least in this, that it is, as a rule, obstinately recurrent, and that the patency of the channel, even if re-established, can only be maintained by the regular passage of a probe at short intervals of time. The little operation is somewhat painful, and is only easy to practiced hands. False passages are of constant occurrence,[1] and the rough or careless use of the probe may itself be an exciting cause of inflammation which will do fresh mischief. Obstruction of the duct is very common in quite young children, in whom it would be impossible to use the probe without an anæsthetic, and in whom the chances of doing harm are enormously greater than in adults. The obstruction itself is a comparatively trivial matter, as long as the over-distension of the sac, and the consequent formation of abscess, can be avoided.

On these grounds, whenever I am consulted by a patient whose nasal duct is occluded, but, as yet, without inflammation, I advise submission to the inconvenience, coupled with the

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[1] [Only in unskilful hands.]

precaution of emptying the sac so frequently by pressure, that over-distension and its consequences cannot occur. It soon becomes a matter of habit to compress the sac, every half hour or so, by the finger covered with the pocket handkerchief, and thus to remove the secretion. At the same time an astringent lotion—generally a solution of five grains of acetate of lead in an ounce [or two] of water—may be dropped into the inner canthus night and morning; and in this way the patient may [sometimes] be kept in comfort for an indefinite number of years.

When, however, there is already a tendency to inflammation, evinced by some redness about the caruncle and plica semilunaris, by some tenderness of the distended sac, and by the purulent or muco-purulent character of its contained fluid, it is generally well to make an endeavor to overcome the obstruction. For this purpose, the lower eyelid should be drawn outwards and rendered tense with one hand, while, with the other, the surgeon introduces the beak of Weber's knife into the corresponding lacrymal punctum The punctum itself forms a vertical cylinder, about a line in height, placed at the end of the horizontal canaliculus, which therefore joins it at a right angle. Remembering this right angle, and so guiding the beak as to straighten out the channel, the surgeon carries the knife horizontally along the canaliculus, with its cutting edge upwards, until it enters the lacrymal sac, and its blunt extremity is arrested against the bone. Keeping this extremity in contact with the bone, and keeping the eyelid tense, the knife is raised from the horizontal to the perpendicular position, and it divides the whole length of the canaliculus during the movement. The surgeon then takes a probe, generally the largest[1] of Bowman's series, and passes it horizontally along the divided canaliculus into the sac. When it is arrested by bone, the probe must be raised into a vertical position, so that it crosses the supra-orbital notch; and it is then pushed down to the bottom of the sac, and made to engage itself in the upper part of the nasal duct. The probe is not quite straight, and hence, if it does not hit the duct at once, simple rotation of the shaft will cause the extremity to describe a small circle, and in the course of this circle the opening will probably be found. When the surgeon is sure that he is in the right track, he pushes the probe steadily downwards, through any resistance of an elastic character, until its extremity strikes upon the floor of the nose. When the obstruction is of long standing, it is often very firm and difficult to overcome; but it never presents the unyielding opposition of bone. After being suffered to remain a few minutes, the probe is withdrawn. The lips of the incision in the canaliculus must be separated with a probe daily, for the first two or three days, or until they have lost all disposition to cohere. The sac must be diligently emptied by pressure, lead lotion dropped into the inner corner of the eye, and

[1] [Preferably No. 3 or No. 4 of Bowman's series of six probes]

the probe passed again in three or four days, when, if all is going on well, there should be less resistance than at first. In that event, the probe should be passed once or twice a week for three or four weeks, and then, in a small percentage of cases, the stricture will be permanently cured.

FIG. 63.

In the majority, however, this fortunate result will not be obtained, and contraction of the duct, with a return of the original symptoms, will sooner or later occur. I then employ the method of Stilling. By this, the probe is first passed through the stricture as before, then withdrawn and replaced by Stilling's knife (Fig. 63) which is pushed down until its blunt extremity touches the floor of the nose. It is then made to divide all the soft parts within the bony channel of the nasal duct, in three or four radial directions, cutting quite up to the bone in each. When this is effectually done, the knife should be loose in the channel, and blood should flow freely from the nose. The knife is then withdrawn, and no other treatment is employed. Again in a few instances, a complete cure will be obtained; but, far more frequently, contraction will take place after this plan as after others. When it does so, I regard the stricture as incurable. I have tried all manner of schemes, the frequent passage of silver probes of all sizes and patterns, the insertion of lead or silver probes to be worn for periods ranging from three weeks to six months, dilatation by bougies of catgut or laminaria, and the injection of various lotions by syringes. At one time I had a syringe with a probelike nozzle, by which I could convey injections to any part of the duct. I think I may say that in every such case without exception the last state of the patient has been worse than the first; and I have now abandoned every one of the practices referred to. After a single fair trial of the probe, followed, if necessary, by a single fair trial of Stilling's operation, I arrange the cases into two classes, those in which the patient may be kept comfortable by regularly emptying the sac and by the use of astringents, and those in which the sac is chronically inflamed and a source of perpetual trouble. In the latter I adopt a plan first introduced by Magne,[1] and destroy the inflamed sac by caustic. For this purpose a vertical linear incision is made through the skin of the cheek, by which the sac is laid open in its entire length, and emptied of its contents. When bleeding has ceased, the cavity is lined with a paste made of chloride of zinc, flour, and water, which is carefully applied to the whole of the mucous membrane, the skin being protected by oil, or by a speculum made for the purpose, by which the lips of the wound may be held apart. A poultice or water-dressing is applied, and in due time the sac is

[1] [The destruction of the sac by caustic was advocated before Magne (1850) by Nannoni (1748), Beer (1817), and many others.]

thrown off as a slough. The resulting cicatrix is inconspicuous, but the contraction from loss of tissue usually occasions some slight displacement of the lower lid. There will still be watering of the eye under any increase of secretion; but the discomfort and discharges arising from the inflamed sac are permanently removed. Magne originally employed chloride of antimony as his caustic, and various preparations have been recommended by other writers; but in my hands the chloride of zinc has been most serviceable.

[By far the most elegant operation for laying open the lacrymal sac, preparatory to its destruction by caustics, is that described by Dr. C. R. Agnew (*American Practitioner*, January, 1871, pp. 12 and 13 : "With Weber's knife I slit up both canaliculi from the puncta to the lacrymal sac. I then cut the sac wall intervening between the two canals. This carries me behind the tendon of the tensor tarsi, leaving it intact. I then with a small strong scalpel, make a sweeping cut upward, and then downward, so as to split the wall of the sac that looks toward the eye, until I can introduce a retractor into the cavity of the sac. When I can do so, I draw the anterior wall of the sac with the overlying palpebral commissure toward the side of the nose, and thus reveal the sac cavity. I then apply either fuming nitric acid or potassa fusa to the sac lining and the canaliculi until I feel sure that no mucous lining is left. I then wash out carefully, and allow the anterior sac wall and palpebral commissure to fall back into place, when the sloughing and inflammatory processes destroy both sac and canaliculi; and no one could tell from any external or conspicuous signs that an operation for the destruction of the sac had been done."]

Instead of destruction of the lacrymal sac, extirpation of the lacrymal gland has been performed and recommended by several surgeons; and, in this country, especially by the late Mr. Lawrence, who published an interesting paper on the subject in the *Ophthalmic Review*. The operation is not followed by any injurious dryness of the conjunctiva, and the tears seem hardly to be missed. But the lacrymal gland is often somewhat composite, and small, detached portions of it may be situated at some little distance from the main body. These detached portions are liable to be left behind, although their excretory ducts are divided; and their secretion may then infiltrate the neighboring tissues, producing great swelling, and sometimes troublesome and prolonged inflammation, followed by abscess. In order to avoid such consequences it is necessary to make a very free external incision, which should be close under the upper and outer margin of the orbit, and to search for all accessory glands with great care. If these precautions are taken, the ultimate results of the operation may be extremely good; and I have lately heard from my friend Dr. Andrew, of Shrewsbury, that it has been very successful in his hands. As far, however, as my own experience will justify a conclusion, I think that, on the whole, the destruction of the sac is the better of the two methods of treatment.

When the patient is first seen with the sac acutely inflamed, and evidently containing pus, unless this is actually pointing on the cheek, an attempt should be made to prevent the formation of fistula. For this purpose the canaliculus should be slit up, and, if the pus does not then escape freely, the opening of the canaliculus into the sac may be enlarged by a fine, slender knife. If the abscess is pointing, and the skin too thin to be saved, or if an opening has been already formed, it is best to use soothing applications, and to wait until all tenderness and pain have subsided before any attempt is made to cure the stricture. If this can be done, the fistula will either heal, or at least cease to be a source of inconvenience.

[In the treatment of disease of the lacrymal passages no single plan will always succeed. In many cases of distension of the sac by tears and mucus, or of these mixed with pus, but little more need be done than to provide a free exit for the distending fluids. This is best done by slitting the upper or lower punctum and canaliculus, or in some cases both; the contents of the sac can then be pressed out by the patient as often as they accumulate, and the case may recover without further surgical interference. Having thus gained access to the sac, it is often desirable to explore the whole length of the nasal duct by carefully passing one of Bowman's probes, preferably No. 3, of the series of six; this is often done at once, but it is better in many cases to wait a few days before using the probe. We thus detect any stricture, or opposing fold of membrane, as well as any disease of the bony wall of the sac or nasal duct. At this stage we may properly divide any constricting bands by the aid of Agnew's knife (Fig. 64), having first carefully determined their situation and extent by the use of a probe furnished with a bulbous tip. If we detect denuded or carious bone, we must promote healing by maintaining a free exit for the pus, conjointly, perhaps, with the daily use of astringent or antiseptic injections. In some cases the disease of the bone is dependent upon constitutional syphilis, in which case it often yields promptly and completely to the internal administration of iodide of potassium in full doses.

FIG. 64.

In abscess of the lacrymal sac we must give exit to the pus as early as possible, and this can often be accomplished only by an incision through the skin. In young infants we have seen perfect recovery follow the opening of the abscess; but it is well, in most cases occurring in older persons, to slit one of the canaliculi and explore the nasal duct as soon as the inflammatory swelling has subsided, dividing also any stricture by means of Agnew's knife. With this degree of interference, repeating the probing a few times, at intervals of a week or two, the external opening will generally heal, and the case either wholly recover or so far improve as reasonably to satisfy both surgeon and patient. Even chronic suppuration of the sac, with dis-

charge of pus through an external opening, will as a rule yield speedily to this treatment, and the fistulous opening, if not of very long standing, will promptly heal.

The treatment of simple chronic catarrh, or of chronic suppuration uncomplicated with fistula, is often tedious, but is by no means generally discouraging when the plan indicated above is intelligently and patiently followed; in many cases of stricture, too, the internal division of the obstruction suffices permanently to remove it, or prepares the way for its permanent cure by the occasional use of Bowman's probes. Certain cases will occur, however, in which the stricture is very resistent, and obstinately recurs after dilatation. In such cases a style, introduced through the slit canaliculus and worn for several weeks or months, may sometimes be employed with great advantage. The plan of using styles introduced through the dilated punctum in the treatment of stricture of the lacrymal passages was suggested by Mr. Travers (*A Synopsis of the Diseases of the Eye*, third edition, London, 1824), and has been warmly advocated by Dr. Hays, of Philadelphia (*Lawrence, on the Diseases of the Eye*, edited by Isaac Hays, M.D., Philadelphia, 1854, pp. 920–2); but it is only since the introduction by Mr. Bowman of the operation for slitting the canaliculus that it has been possible to use styles of sufficient size to meet all the requirements of the case. A most important condition of permanent good results from the wearing of styles is that the style worn last shall be quite large, so that, after its removal, the inevitable contraction of the canal may still leave a way open for the passage of tears and mucus into the nostril. This seems to have been understood by Scarpa and those of his followers, who have employed very large leaden styles, introduced through an opening in the skin, and has more recently been enforced by Dr. E. Williams, who has long employed, as a general method, large styles of silver, introduced through the slit upper canaliculus, and worn constantly during the whole course of treatment (*Archives of Ophthalmology and Otology*, I, I, pp. 40–52). The styles used by Dr. Williams range from one and a half to two and eight-tenths millimetres in diameter, and the whole duration of the treatment is stated to be generally about three months. We are in the habit of treating some of the severer cases by this method, using, however, styles of soft lead instead of silver, and not exceeding a diameter of two millimetres for the largest; and our experience appears fully to justify Dr. Williams's statement, that in his hands it has entirely superseded the destruction of the sac by caustics, in all cases in which the nasal duct is not absolutely impassable by a probe.]

Occlusion of a lacrymal punctum is readily discoverable by the naked eye, or, at all events, by the aid of a lens; the punctum resembling a little papilla or vesicle, and presenting no central aperture. [It is sometimes congenital.] When only the orifice is closed, a careful puncture with a common sewing needle, followed by the passage of the finest lacrymal probe, may restore the

natural condition. Obstruction in the course of a canaliculus can only be discovered by a probe. In the natural state, when the eyelid is rendered tense, the smallest probe, if once guided round the angle between the punctum and the canaliculus, will glide freely along the whole length of the latter until it crosses the lacrymal sac and strikes against the bone. When the canaliculus is obstructed, the probe is stopped prematurely by an elastic resistance, against which the movement of its point may be both seen and felt by the operator. An attempt may be made to overcome such an obstruction; but it will be almost certain to reunite. In a few cases the canaliculi have been choked by concretions, mostly the so-called dacryoliths, or masses of saline deposit from the tears, which have also been found in the gland-ducts In one instance I removed from the canaliculus of the lower lid a solid mass of fatty matter of very appreciable size, which certainly could not have been introduced by the punctum, and the source and origin of which were extremely obscure.

In the cases in which lodgment or overflow of tears is due to displacement of one or both of the puncta by swelling or deformity of the lid, the surgeon must consider whether the cause of the displacement is of a temporary or a permanent character. In the former case, the effect on the tear-passages may be neglected; but in the latter the canaliculus should be slit up to a sufficient extent to enable the tears to gain access to their natural channels of escape. In some of these cases, as in eversion of the lids produced by chronic blepharitis, the puncta will be difficult to discover, and will be found at last quite on the cutaneous surface. The condition of the patient is much aggravated by the lodgment of tears, and to slit the canaliculis effectually, and to maintain the patency of the slit, will generally diminish the existing discomfort in a marked degree, and will often lead the way to much permanent improvement.

CHAPTER VII.

DISEASES OF THE CONJUNCTIVA.

The conjunctiva, as a mucous membrane, is liable to a superficial inflammation which is attended throughout by hyperæmia and swelling, at first by dryness, and afterwards by increased secretion, which may be either mucous or muco-purulent, or may pass on to attain a distinctly purulent character. A well-known form of the disease is the ophthalmia neonatorum, or purulent conjunctivitis

of infants, which usually commences within the first few days of life. It is probably often a consequence of direct inoculation with the maternal secretions; although the late Dr. Ballard was accustomed to maintain that it was due to no other cause than the improper exposure of the newborn eyes to light, and to assert that he had banished it from his practice by acting upon this opinion. His views have not, as far as I know, been confirmed by any other observer; but there can be no doubt of the propriety of shielding the eyes of an infant from excessive glare. In a large proportion of the worst cases, the patients are the subjects of inherited syphilis. When brought to the surgeon, the lids are usually somewhat reddened, puffy, and swollen, and are often adherent by dried secretion at their margins. When these are separated, the palpebral conjunctiva is seen to be bright-red, villous, and tumid, the ocular conjunctiva covered by a close network of vessels, and the whole surface discharging a tenacious pus. If neglected, the inflammation may soon produce necrosis of the cornea; but as long as this membrane is unaffected the disease is very amenable to remedies. With regard both to prognosis and to treatment it is desirable that a good view of the cornea should be obtained. By patience and gentleness, and by carefully cleansing away the discharge by a stream of warm water, suffered to trickle from a sponge, this may generally be accomplished; but it is better to go without the information than to obtain it by rough handling. I have known an ulcerated cornea ruptured and the crystalline lens squeezed out by the unskilful efforts of a surgeon to ascertain the exact state of the case. When the lids are very tumid and readily everted, it is usually best to lift the upper lid with a small retractor, the use of which obviates all risk. If the cornea is bright and clear, the only treatment required will be cleanliness and the careful application of an astringent. Some surgeons use an alum lotion, but I have no confidence in it, and prefer a solution of nitrate of silver of the strength of two grains to the ounce. The infant's head being placed in the same way as for examination, the pus should be gently and thoroughly washed away with a small fine sponge and clean, warm, soft water; a stream being allowed to trickle from the sponge upon the lids while these are gently separated by the fingers. Another sponge may be so disposed as to receive the overflow of water; and time must be taken to render the cleansing complete. Some recommend a syringe, but the stream afforded by it is apt to be jerky and unduly forcible, and the small sponge is in every respect better. When the washing is finished, the eyes must be very gently dried by the application of bits of soft absorbent rag, and then a drop or two of the nitrate of silver lotion should be suffered to fall fairly between the parted lids. Finally, the margins should be anointed with cold cream or spermaceti ointment to prevent adhesion from the drying of the discharge. The whole process thus described should be repeated every four hours, and there will soon be sufficient evidence of improvement to allow of this interval being extended to six, eight, or even twelve

hours. Within a week the cure is usually complete. The surgeon should, as a rule, show the mother or nurse how the application is to be made. If he is content with mere description, the chances are that his directions will be imperfectly followed. He should make it clearly understood that the discharge is highly contagious, and that it would produce the same disease in a most dangerous form in any other eyes to which it might be accidentally conveyed. The sponges and towels used for the infant should be carefully set aside, and water used for the eyes or for the hands of the attendants should be immediately thrown away.

If the purulent ophthalmia of infancy is neglected, or imperfectly treated, it may soon implicate the cornea, and then becomes a source of exceeding peril to the sight. Under this phase I shall have to speak of it again in a subsequent chapter, but I may say here that it is supposed to be the cause of nearly half the existing blindness of this country, although with only the most ordinary care, the disease ought to terminate in complete recovery in every instance. Very often, of course, medical advice is not sought until the time for treatment has gone by. Poor women are attended in labor by ignorant midwives, and if the infant has ophthalmia no one takes much heed of the occurrence. I fear, however, that in many of the cases medical men are greatly to blame. Every accoucheur ought to be on the alert with regard to a malady so easily cured at its commencement, so dangerous if permitted to make progress. He should warn mother and nurse to send for him without delay on the first appearance of swelling or discharge, and he should spare no pains in making sure that the necessary local remedies are used in the right way. I have repeatedly been called to infants for whom the accoucheur had indeed prescribed a lotion, but without proper directions for its employment, so that it had been poured over the face, or upon the clothes, or down the back, or anywhere but into the eyes, by a nurse who was wholly unaware of the importance of the application. I have even seen trust placed in the employment of a wet-nurse, to the absolute exclusion of local treatment; and I have seen eyes lost by both these errors. I cannot too strongly express my conviction that no infant should ever lose its sight from this affection; and that sight cannot be so lost under the observation of a medical man, except as a consequence of neglect or want of knowledge of a very flagrant character.

[This last assertion of the author appears to us to be by far too sweeping, and therefore liable to convey a mischievously wrong impression. It has occurred to us, in at least two instances of this disease, to see an eye lost, in one case both eyes, from ulceration of the cornea, although careful and efficient local treatment had been followed from the beginning. In one of these cases the mother was known to be suffering from a recent gonorrhœa, and there was also a strong suspicion that the child had inherited a syphilitic taint; in the other case, which seemed to be doing perfectly well, a digestive derangement, incident to an unauthorized change of the wet-nurse, was accompanied by ulceration of both corneæ, which,

in one eye, led to perforation and extensive staphyloma. The treatment advocated by the author seems to us eminently judicious, but we also think well of a collyrium of alum (gr. iv or vi ad ℥j), used hourly or sometimes oftener by the nurse, and supplemented by an application of a solution of nitrate of silver (gr. ij or v ad ℥j), daily, or perhaps twice a day, by the surgeon. In cases in which the cornea is already ulcerated, the stronger nitrate of silver solution should not be allowed to come in contact with the cornea, at least until it has expended most of its activity upon the conjunctiva of the lids. Absolute cleanliness and good nutrition are both of the first importance.]

When inflammation of the conjunctiva attacks patients beyond the age of infancy, it sometimes assumes a sporadic, sometimes an epidemic character. The sporadic cases may be due to ordinary catarrh, or to irritation set up by dust, noxious vapors, or foreign bodies, or to the hyperæmia induced by overwork of the eyes in persons who require spectacles, but are not furnished with them. The conjunctiva is more or less injected, and the eyes feel as if some gritty substance were under the lids, which are usually somewhat stuck together by discharge after sleep. The diagnosis of uncomplicated conjunctivitis may be arrived at with certainty when there is no vascularity or diminution of the transparency of the cornea, even at its margin, no loss of lustre of the iris, no diminished mobility of the pupil, no impairment of vision, and when the injected vessels can for an instant be wholly emptied right up to the corneal margin by slight pressure with a finger through the medium of the eyelid. A simple astringent lotion of nitrate of silver, or of sulphate or chloride of zinc, of from two to four grains to the ounce, suffices for the speedy cure of the majority of such cases. The selected lotion should be applied to the inner surface of the lower lid by a brush or quill [or still better by a dropping-tube of glass], and its application should be followed by a brief period of smarting, after which the former uneasy sensations will be much diminished, but will return again in three or four hours. The return should be almost anticipated by the second application of the lotion; and the intervals must be regulated by the recurrence of the symptoms, and increased as they subside. An intractable or recurrent conjunctivitis of slight severity will often be found associated with some error of refraction, such as hypermetropia or astigmatism, or with some chronic irritation of the lacrymal passages. In either case the conjunctivitis must be regarded as an effect likely to disappear with the correction or removal of its cause.

Under certain circumstances, sporadic conjunctivitis may be a disease of great severity. When it is caused by inoculation with gonorrhœal pus, or with the secretion of pre-existing purulent ophthalmia, of whatever kind, it rapidly produces extreme swelling and profuse discharge, often attended by ulceration or sloughing of the cornea, and ending in loss of sight. Between these cases and those of the mildest kind it is impossible to draw any line of

demarcation. There may be forms of conjunctivitis in which the discharge is not contagious; but, if so, there are no known signs by which these forms can be certainly distinguished from others; and "a cold in the eyes" of trivial character not seldom runs through a household, and attacks some member of the family more severely than the rest. It may be said, therefore, that simple conjunctivitis ranges from a very slight affection to the most virulent form of purulent ophthalmia; and widely different as are the extremes of the scale, they fade into each other by imperceptible gradations. Severe conjunctivitis has four especial sources of danger. It tends to produce hypertrophy of the papillæ of the membrane; and the hypertrophied papillæ, in their turn, tend to produce and maintain inflammation of the cornea, with development of vessels under its epithelium, and consequent opacity of its substance. It tends to produce discharge of a contagious character, capable of reproducing the disease in others, not only by direct communication, as by actual contact through the intervention of fingers, sponges, or towels, but also through the medium of the atmosphere, since the discharge finds its way by the lacrymal passages into the nose, and is carried off with the particles of watery vapor in the expired air. It tends to produce ulceration or necrosis of the cornea by interference with its nutrition; and hence large opacities, anterior synechiæ and their consequences, partial or complete staphyloma, and thus, in many ways, impairment or even total loss of vision. Lastly, it tends to pass into a state of chronic hyperæmia, which may endure for months, and which the smallest spark of irritation may rekindle into active and formidable disease.

The papillæ of the conjunctiva are analogous to those of the dermis, and are situated immediately beneath the epithelium. They are small and scattered in the vicinity of the free margins of the lids, larger and more numerous near the attached borders of the cartilages; and still numerous, but less elevated and with broader bases, in the regions of the palpebral folds. On the ocular conjunctiva they are few in number, or even altogether wanting, except in a narrow zone immediately around the corneal margin, and chiefly in its upper and lower portions. They are formed of connective tissue and vascular loops, and in the healthy state cannot be recognized by the unaided vision.[1] After a short

[1] ["The conjunctiva (of the eyelids) is traversed in every direction by groovelike depressions. These . . . . cross each other and divide in such a way as to form numbers of irregularly-shaped islands, which have been described by authors as papillæ or papilliform elevations. . . . . Near the edge of the lid these furrows are numerous but shallow; further above they become deeper, and at the palpebral fold they pass over without any well-defined limit into the depressions between the longitudinal folds which give to this portion of the conjunctiva its wrinkled appearance.

"But besides these, true papillæ also exist in the conjunctiva. . . . . Small isolated papillæ are found even at a short distance from the margin of the lid, and these increase in height and breadth as we approach the fornix. . . . . Upon the eyeball the surface of the conjunctiva exhibits well-developed papillæ, which diminish in

period of conjunctivitis, however, or of the irritation due to the presence of a foreign body, if we evert the upper lid, its inner surface, especially in its upper portion, will be seen to be studded over with fine red points, like grains of dark-red sand. These are congested papillæ; and if the cause of the congestion be removed they soon return to their normal invisibility. After a while, however, congestion passes into hypertrophy; the more rapidly in proportion to the youth of the patient and the severity of the inflammation. In quite an early stage of the purulent ophthalmia of infants we find the conjunctiva of the lids and of the palpebral folds distinctly villous; the enlarged papillæ standing out as numerous and considerable prominences. As a sequel of longer continued inflammation in the adult, we find a similar condition almost permanently established, or, at least, requiring persevering and well-directed treatment for its removal. The lids are then said to be "granular," and, in such cases, there usually coexists with the granular lids a state of chronic vascularity and consequent turbidity of the cornea. The word "granular," as applied to this condition of the lids, is objectionable, because it does not distinguish the hypertrophied papillæ from granulations of another kind, which have their seat in the lymph-follicles, and will be more fully described hereafter. For the former, the phrase "papillary granulations," and for the latter the phrase "follicular granulations" will be found sufficiently explicit. The papillary granulations are often large and salient, dark-red or livid in color, and seated upon folds of hypertrophied membrane which spring into great prominence when the lids are everted. After infancy, they are usually the indications of a former conjunctivitis the acute stage of which has passed away. In the early periods of inflammation the papillæ are to be regarded chiefly as increasing the extent of the inflamed surface and as adding to its hyperæmia; so that they both intensify the degree of the morbid process and enlarge its area, besides affording material for the formation of inflammatory products. In the later periods they are important as mechanical irritants of the cornea, and as the seat of a chronic and to some extent passive congestion, which is, from its very nature, in a high degree rebellious to treatment.

The discharge of conjunctivitis, in mild cases, is only a slight exaggeration of the natural secretion of the membrane. Very soon, however, it may assume first a muco-purulent, and then a distinctly purulent character; and during this progress it acquires contagious properties. There can be little doubt that the activity of the contagium bears a general relation to the intensity of the inflammation, and to the purulent character of the secretion; and as little that certain varieties of conjunctivitis are more early contagious than others. But it is not possible to assert the non-contagiousness of any inflammatory conjunctival discharge, or to

size and number toward the cornea, and in its immediate vicinity disappear altogether." Stricker, in *Stricker's Manual of Histology*, chap. xxxvi, viii. (Translated by Henry C. Eno.)]

point out any character or combination of characters which indicates when the quality of contagiousness begins or ceases. It is obvious that, in this respect, much must depend upon the soil on which the contagium is received; and that a secretion which would be innocuous to a healthy eye might be sufficient to produce inflammation in one predisposed to it, either by constitutional causes or by the existence of prior irritation of any kind. In a regiment, school, or other crowded community into which ophthalmia has once found entrance, we see the disease constantly re-excited in persons who are seemingly convalescent; the explanation being that their eyes, still abnormally irritable and vascular, have no power to resist the action of the particles of discharge which are continually floating in the atmosphere, or which are communicated by methods still more direct.[1]

Ulceration or necrosis of the cornea is the morbid process through which inflammation of the conjunctiva is most prone to occasion actual loss of sight; and it appears to depend upon an interruption, probably in great part mechanical, to the ordinary corneal nutrition. The first indication that the cornea is threatened in conjunctivitis is given by slight elevation and irregularity of the epithelium at its margin. In the more violent and acute cases, with purulent discharge and great swelling of the lids and of the conjunctiva of the eyeball, this irregularity of the epithelium is apt to be soon succeeded by a general haze or cloud, which may be the precursor of a process of simple death and disintegration of the corneal tissue; but which, in cases of less severity, is usually followed by an encroachment of vessels upon the cornea, by inflammation of its substance, or by ulceration of a more or less inflammatory type. Under the influence of inflammation alone, the cornea may not only sustain permanent impairment of its transparency, but also softening of its tissue, tending to alteration of its curvatures by the operation of the fluid pressure from within. Ulcers, even if small and superficial, may dot the corneal surface not only with cloudy patches, but also with facets disturbing to vision; and when they are deep, they produce permanent and absolutely opaque cicatrices. If they perforate the cornea, they are commonly followed by prolapse of the iris into the resulting opening, and by its permanent adhesion therein; and the "anterior synechiæ" thus produced not only feed the cicatricial tissue by the vessels of the iris, and render it more extensive and more dense than it would be otherwise, but also by restraining the movements of the pupil, and by thus dragging upon the nerves of the iris and of the ciliary region, they frequently produce deep-seated and ultimately destructive changes. When the original ulcer is both large and perforating, the result is necessarily a staphyloma, which must usually include, if not the whole cornea, at least so large a portion of it as to render the rest scarcely at all available for the purposes of vision.

[1] [During convalescence from any superficial inflammation, the eyes retain for a long time an increased sensibility to all kinds of irritating influences.]

The chronic hyperæmia which may follow conjunctivitis will usually be found to lie hidden beneath the eyelids, and to be absent from that portion of the eyeball which is exposed to the air by the natural opening of the palpebral fissure. It is probable that the air constringes and braces the conjunctival vessels, and assists in restoring them to healthy tone and normal calibre. However this may be, it is common to find, in communities in which conjunctivitis has prevailed, many persons whose eyes would at first sight be said to have recovered, but in whom undue vascularity will be found lurking, so to speak, in the palpebral folds, and giving evidence that the recovery is rather apparent than real. In such cases, the eyes have in no sense recovered their power to resist injurious influences, and they are liable constantly to suffer relapse where such influences are in operation. The tenacity with which ophthalmia will often cling to an institution is due, almost entirely, to the relaxation of vigilance with regard to half-cured patients, who are often improperly permitted to resume the freedoms of health.

The full severity of the communicable or epidemic form of conjunctivitis does not become apparent until the discharge is received upon eyes which are prepared to suffer by the pre-existence in them of follicular granulations. What is now known as contagious ophthalmia was first introduced into Europe in the beginning of the present century by the return of the French army from Egypt, and its ravages speedily attracted the attention of military surgeons in all countries. The "papillary granulations" produced by the conjunctivitis were recognized by Eble in 1828; but it was not until 1848 that the follicular granulations were described. In that year contagious ophthalmia broke out among the soldiers of a Prussian regiment employed against the Danes. Dr. Löffler, the surgeon of the regiment in question, instituted a careful daily inspection of the eyes of all the men, and discovered that the conjunctiva, in many who showed no other trace of disease, was studded by pellucid granules which elevated the epithelium. He also found that the eyes in which these granules existed were those in which the ophthalmia was afterwards developed; and he came to the conclusion that the granules were the first stage of the disease, and the exciting causes of the subsequent phenomena. At a later period, Dr. Frank and Dr. Marston showed that these pellucid granules, which had by that time received the expressive name of "sago grain" granulations, were common among soldiers who were placed under insanitary conditions of living; and it became in time fully established that they did not necessarily give rise to inflammation. They were manifestly strongly predisposing causes, but they did not appear to be exciting causes of acute disease.

The "sago grain," or follicular, as distinguished from the papillary granulations, are little rounded eminences, the appearance of which the term "sago grain" almost sufficiently describes—if it is borne in mind that the sago is supposed to be boiled. They are

colorless and semi-transparent, slightly elevated above the general level of the conjunctiva; and they may be found, if anywhere, on the retrotarsal fold of the lower lid, in the neighborhood of the outer canthus. Anatomically they consist of mere assemblages of lymph-cells, the increase of which has wasted or displaced the meshes of the areolar tissue, so as to form cavities in which the cells are contained. A controversy was carried on for many years on the question whether these "granulations" are purely pathological products, or only exaggerations of a physiological structure. The former view was strenuously maintained by Stromeyer, Henle, Blumberg, Wolfring, and others; the latter by Krause, Kleinschmidt, and Huguenin; and the question has been finally settled in the latter sense by Dr. Schmid, by researches carried on in Professor Arnold's laboratory at Heidelberg. Schmid has found that in newly born animals the conjunctiva consists of a subepithelial adenoid tissue, in which lymph-cells are generally distributed; but that, soon after the commencement of independent life, the cells begin to form aggregations, and to assemble themselves into distinct follicles, which are part of the normal structure. Under certain conditions, these follicles undergo enlargement and distension, which are liable to be followed by various inflammatory or retrogressive changes, and indirectly to produce many disastrous consequences.

Although the absolutely exciting causes of this follicular hypertrophy are unknown,[1] and although isolated examples of it may every now and then be seen in apparently healthy persons, who are living under favorable sanitary conditions, yet there can be no doubt of the general correctness of the view that it affords a delicate test of the sanitary state of a community. A school or regiment in which cases of follicular granulations are numerous, even though there may be an entire absence of active mischief, should be set down as having something radically wrong in its condition or management, and as being likely to suffer from contagious ophthalmia before long. In like manner, when contagious ophthalmia has once appeared, the children or persons who have "sago grains" still in a passive state may with tolerable certainty be pointed out as the next victims to the disease.

When the secretion from an inflamed conjunctiva is in any manner conveyed within eyelids in which follicular granulations exist, or when, from any other cause, the granulations take on an inflammatory action, the appearances first produced are highly characteristic. The enlarged follicles, by their prominence, sepa-

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[1] [It appears certain that simple conjunctival hyperæmia, often leads to "follicular hypertrophy" ending in true trachoma. Such cases often develop under our eyes, in patients first attacked by simple catarrh, but who present themselves irregularly for treatment. We also meet with cases of corneal abrasion, or other slight injury, in which a state of chronic hyperæmia, due to exposure and neglect of proper treatment, is attended by the development of "follicular granulations" in a conjunctiva previously to all appearances perfectly normal. It is quite true, however, that in a very large proportion of cases, the appearance of these granulations precedes the outbreak of inflammatory symptoms.]

rate the surface of the lower lid somewhat from the eyeball, although leaving its tarsal margin still in contact, and they thus give an appearance of general fulness or projection to the lid. When the lid is everted, the summits of the follicles are conspicuous, by their whitish semitransparent aspect, on the congested conjunctiva; but before long they are apt to be concealed by increasing swelling and hyperæmia, and by the development of papillary granulations. The inflammation itself runs a course which is in no way distinguishable from conjunctivitis of an ordinary kind, although it is more liable to be ultimately followed by cicatricial shrinking of the conjunctival tissue, which may occasion incurvation of the tarsal cartilages, and may thus bring the lashes to rest upon the eye, besides destroying the natural smoothness of the palpebral surfaces. On the whole it may be said, as was first, I believe, pointed out by Peltzer, that there is much analogy between the history of follicular granulations and the history of tubercle. The granulations bear a general resemblance to the enlarged glands of strumous subjects, and are at least an expression or result of unfavorable sanitary conditions; they may for a long time remain latent or passive, and may at last disappear by mere shrinkage or degeneration, or they may undergo inflammation or ulceration, or may give rise to these conditions in the parts around them. In any case, the effects produced by their presence, or by the changes through which they pass, will be greatly dependent upon their exact position, and upon the degree in which they disturb the tissues among which they have appeared. Moreover, it seems to have been established, by the observations of Dr. Welch, that the liability to follicular granulations, under similar circumstances, is distinctly greater in children than in adults, and in young adults than in persons of middle or advanced age.

When we come to apply the foregoing considerations to the facts of practice, we find that contagious ophthalmia, which, when it occurs in families, is usually a disease of no great severity and easily guided to a termination in recovery, is liable to assume highly formidable characters as soon as it invades any large community of persons who are placed under insanitary conditions. It was once a dreaded scourge of armies; at present its worst effects are seen most commonly in pauper schools. If we inquire into the condition of such a school, in which ophthalmia has for a long time been prevalent, we shall usually find the following to be the most prominent facts of the case.

In the first place, the inmates are children who have nearly all been insufficiently, or at best irregularly fed, whilst under parental control; and many of them, as orphans, are the presumptive inheritors of some form of constitutional disease. But they have mostly been accustomed, from the time when they could walk alone, to the liberty of street Arabs; and have been saved, during this period, from the operations of many of the insanitary conditions of their wretched homes, by their free and constant exposure to an atmosphere which, if not of the best, would at least be many

degrees more wholesome than that of a crowded schoolroom. When they are brought into the school, it does not always happen that they receive a proper diet; because the scale on which they are fed is liable to be determined by authorities who are unacquainted with the dietetic requirements of growing children, and who do not seek advice from those who are capable of instructing them—or else, like a coat made by a Laputan tailor, the dietary of the school is arranged upon some sham scientific calculation of the daily waste of the body, and of the number of grains of carbon and nitrogen by which this waste can be repaired. It has been well said that the tastes are the expressions of the physiological wants of the system; and all who are accustomed to children know that their tastes are often apparently capricious. They will reject this or that customary article of diet, or they will ask for something to which they have taken a fancy; and the circumstances of family life are usually such as to admit of their being moderately indulged in these respects. The so-called street Arabs, moreover, soon learn to forage for themselves; and it is probable that they are able to vary their diet in many ways that assist to maintain them in health and good condition. But the regulations of a school exclude variety; and, if the fixed scale should also exclude any form of aliment which ought at least to be occasionally given, there is no possibility of the deficiency being made up from accidental sources of supply. The *Lancet*, speaking of the epidemic of ophthalmia at the North Surrey Schools at Anerley in August, 1872, said:

"The diet is poor. Our visit was on a Saturday afternoon. We inquired of a promiscuous group of five girls what their dinner had been that day? With no air of complaint they said, pudding and potatoes. What yesterday? Rice milk, and treacle over it. The day before it was meat pudding; on Wednesday, Irish stew. There are three meals in the day. The breakfast consists of about three-quarters of a pint of cocoa and milk, five to six ounces of bread, and half an ounce of butter. Dinner on Mondays, Wednesdays, and Saturdays has no meat in it. And there is nothing after this till supper, which consists of half a pint of milk mixed with an equal quantity of water. This diet will not sustain health; and when the children break down they cannot be got up again by any amount of quinine and iron. Irish stew has been lately added on Wednesdays—we believe on the strength of Dr. Duke's advice."

Overcrowding is common enough in the homes of the poor; but it is, as a general rule, overcrowding tempered by crevice ventilation. The houses are ramshackle, the windows are broken, the doors gape from the lintels and side-posts, the chimneys are low, and atmospheric currents flow through in all possible directions. In the above-quoted *Lancet* report, it is said that the children at Anerley had a short time previously slept in dormitories which gave only 290 cubic feet to each, but that the number of sleepers had been reduced from 40 to 34. A room which gave 290 feet to

each of 40 occupants would give 341 feet to each of 34; and from this scanty allowance we must deduct the space filled by the 34 beds and their bedding, and by the clothes of the children. When I visited Anerley in the afternoon I found the dormitory windows open, and the atmosphere sweet and pure; but I observed that the doors and windows were well fitted, and learnt that they were closed at night. I asked an official if he had ever put his head inside one of these dormitories at five in the morning. He replied that he had done so, and admitted that the stench of the room was "awful." In the schoolrooms, as in most other schoolrooms, there was no sufficient supply of fresh air during working hours; and the teachers and pupils were probably unconscious of the gradually increasing deterioration of the atmosphere. Both in dormitories and schoolrooms this deterioration is, I believe, greater than can be accounted for by the changes produced in the air by respiration alone. The cutaneous exhalations of unhealthy and imperfectly fed children are themselves exceptionally offensive; and in spite of some considerable parade about baths and lavatories, an ordinarily sensitive nose at once discovered that these exhalations had been only imperfectly removed by washing. The clothing of the boys in such schools is often highly offensive, and is probably not always harmless. It is commonly made of fustian or corduroy, and these fabrics have an abominable smell, due, I am informed, to the imperfect removal of bone glue, or other offensive and decomposing animal matters which are used to prepare the warps for the weavers. A piece of new fustian or corduroy may be said to have its texture loaded with organic matter in a state of change, which it gives off freely into the atmosphere. Fifty boys clothed in such material, and packed together in a single room, would furnish emanations which would probably be noxious as well as disgusting; and I believe it is a fact that boys so clothed have suffered more severely from ophthalmia than the girls in the same institutions and under the same management. It is obvious that no argument for the use of fustian in crowded places can be drawn from its use among agricultural laborers, who work in the open air, and in comparative isolation.

If we take all the foregoing elements into consideration, namely, inherited diathesis, insufficient and unvaried feeding, overcrowding and imperfect ventilation of schoolrooms and dormitories, and unwholesome clothing—if we add to these the special influences, such as bad water and the like, which may exist in particular institutions—and if we consider what military experience has taught us with regard to the effect of insanitary conditions, and especially of overcrowding, in producing follicular granulations and contagious ophthalmia in camps and barracks—we shall have no difficulty in coming to the conclusion that the state and regulations of many great schools are quite sufficient to explain the development of these granulations in a large proportion of the children. When the granulations are once developed they are like tinder, to which any accidental circumstance may apply a spark.

A case of catarrhal ophthalmia may be introduced from without, or the granulations of one of the inmates may be irritated by the entrance of dust or some other foreign substance under the lid. If the granulations themselves have come into existence unperceived, it is not likely that the first few cases of "bad eyes" will be rigidly isolated from the rest of the children. The chances are that they will be turned into the infirmary among others, and that when they are a little better they will be discharged from the infirmary to return to their former day-rooms and dormitories. Experience seems to show that a practical community of washing arrangements is one of the most ordinary channels for the propagation of ophthalmia, and such a community exists in most schools of the kind under consideration. At Anerley, for instance, the fixed washing basins had their margins almost in contact; and at one time a few jack-towels were common to a large number of children. "Any contagious discharge," said the *Times*, "would no sooner be wiped out of the eyes of one child than it would be wiped into the eyes of another." Since then separate towels have been provided; but these towels were at first spread out and hung up at the head of each bed in the dormitories; an arrangement the effect of which hardly needs to be stated in words. During sleep, when the eyelids are shut, any contagious secretion would find its way down the tear passages into the nose in greater quantity than in the daytime, and would be carried out into the room in the shape of fine particles suspended in every breath of expired air. It has recently been found that many of the disorders of the tear passages are [occasionally] attended by a great development of leptothrix; and it is highly probable that the same thing may occur in many forms of conjunctivitis. In that case, the floating spores of the fungi would also serve as carriers of contagium, even if the fungoid growth itself may not sometimes constitute the essence of the disease. Ophthalmia and diseases of the skin are very often associated; and Dr. Tilbury Fox has shown that, in a school where ringworm prevailed extensively, the air of the rooms was loaded with elements of its characteristic fungus. If we take such a room as exists at Anerley, in which the cubic space already mentioned is gained very much in the direction of height, in which thirty-four beds were closely packed upon a comparatively small floor area, and in which an open damp towel was hung up at the head of each bed—and if we place in only a few of the beds children who have an early stage of ophthalmia, or who have only imperfectly recovered from a recent attack—it needs nothing but common sense to see that the disease is being absolutely cultivated. It would be possible for infective particles or fungus spores to miss the small spaces occupied by the actual eyes of healthy children; but it would hardly be possible for them to miss the larger surfaces afforded by the extended towels; and when once they are arrested by the towels their transference to the eyes becomes natural and easy.

With the various arrangements that have thus been rather in-

dicated than described, the prevalence of ophthalmia in a school becomes little more than a question of time. When once it prevails, the amount of mischief it may do seems to depend upon uncertain factors. In nearly every epidemic, of whatever kind, there is a special character of benignity or severity; and other things being equal, there can be little doubt that the severity of reproduced disease is influenced by that of the case from which the contagium was derived. It is also influenced in an unmistakable manner by the state and resisting power of the recipient; so that trivial cases are found when the general character of an outbreak is grave, and cases of great severity when the general character is trivial. The speed of diffusion is likely to be much governed by the greater facilities for it which are provided in some institutions than in others; and the persistence of the disease, or the occurrence of numerous relapses, will be promoted by the return of imperfectly cured convalescents to the society of those who are reputed to be healthy. In many cases the managers of a school have been anxious to keep down the numbers in the infirmary for the sake of putting the best face upon things before the public; and it has often happened that the resident doctor has been pressed to discharge children who ought still to be retained under his care. I have obtained from a private source a copy of a report made to a government inspector by a late medical officer of the Hanwell school. It states, among other curious matters, that of 1062 children in the school in question, only 182 had escaped ophthalmia; 163 had suffered from one attack of the disease, 151 from two attacks, 110 from three, 75 from four, 54 from five, 58 from six, 22 from seven, 25 from eight, 7 from nine, 11 from ten, and 204 from more than ten attacks. Concerning the ultimate results of these attacks I have no information; but in another part of the report I find it stated that out of 1195 children, 347 had "granular lids after ophthalmia;" and I have no doubt that in all or nearly all of these sight would eventually be greatly impaired, and that in many it would be wholly lost. Even in mild cases if they become chronic, and especially if they undergo two or three relapses, very serious mischief will usually be done. The eyelids are apt to become more or less distorted; their natural growth is arrested, and the membrane lining them becomes rough and harsh, so that the eyes lose the protection which the healthy lids and lashes afford, and are exposed during the whole of after-life to many injurious influences. The Local Government Board has, therefore, been premature in felicitating itself, in a recently published report, on the fact that out of the very large number of children who were affected at Anerley, "in no one instance has the sight been anything like lost." The changes in the lids constitute one of the gravest dangers of contagious ophthalmia; and these changes occur so gradually that many years may elapse before they are fully produced, and their connection with the original ophthalmia may then easily be lost sight of. They are almost irremediable, because nothing can restore the natural shape, tex-

ture, and pliability of the lids; and because operations for altering the position of the eyelashes are liable to be defeated by the continuance of the contraction, which, in a few months, may reproduce the deformity. The patients are perhaps more forlorn and to be pitied than those of any other class which falls under our notice. They are in a state of constant pain or uneasiness, tormented by every movement of their eyelids, tormented by every particle of dust which falls into their eyes, tormented by their eyelashes, tormented by constant overflow of tears, seldom with sufficient vision to follow any employment, dependent upon the rates or upon charity, half-blind, and wholly miserable. Such are the ultimate results produced by severe conjunctivitis when the patients pass away from under treatment before they are well; that is to say, before residual thickening in the retrotarsal folds has undergone complete absorption. Such is the actual state of many of those who, ten or twelve years ago, were returned as cured at the schools in which the malady was then prevalent; and such will doubtless be the future of many of the children who have suffered at Anerley, even though at present there is no instance in which sight has been wholly lost.

In dealing with conjunctivitis as a sporadic affection, or as it sometimes occurs in a family, there is seldom any practical difficulty; and the cases if seen early will usually respond readily to judicious treatment. The indications are two in number: first, to attend to the general health;[1] secondly, to combat the disease of the conjunctiva by local applications. In selecting these, and in varying them from day to day, there is much room for the exercise of discretion; and in applying them it is necessary to be careful that their effects are limited to the parts actually diseased, and that they are not suffered to irritate the cornea.

In the early stages of follicular granulations, when they are as yet quite passive, or when inflammation of the conjunctiva has only just commenced, the best local application for most cases is the so-called *lapis divinus*, which consists of equal parts of sulphate of copper, nitrate of potash, and alum, reduced to fine powder, fused together, and run into a mould for use.[2] The little sticks may be warmed and softened, like sealing-wax, over a gas flame, and then, by pressure through the medium of a towel, may be readily pointed or flattened into convenient shapes for application. In order to apply them, the patient is directed to look strongly upwards, while the surgeon, with the tips of two fingers, draws the lower lid down to the malar bone. By this manœuvre the

[1] [In a very large proportion of recent cases conjunctivitis is a simple local affection, and requires local treatment only; if the general health is in any way impaired, this should, of course, be attended to, but never to the neglect of local cleanliness and suitable local treatment.]

[2] [The *lapis divinus* is not so much used now as it was by surgeons of a past generation. It is generally thought that a smoothly finished and polished crayon made from a sound crystal of sulphate of copper is, on the whole, to be preferred. A crayon similarly fashioned from a crystal of alum is a much milder and occasionally useful application.]

lower palpebral fold is rendered prominent and is brought fully into view. The surgeon then draws the stick of lapis rather slowly, and with light pressure, along the whole length of the fold; and after having done this he keeps the eyelid held down for a short period, so that the astringent may exhaust itself upon the conjunctiva, and may not be transferred to the cornea when the eye is closed. When the existing irritation is of an acute form it is desirable to wash away superfluous lapis by a camel's-hair brush, dipped in water, before the hold on the lid is relinquished; and, in most cases, the lid should be gently dried with a bit of lint or a soft pocket-handkerchief. The smarting which follows the application, if considerable, may be greatly relieved by freely bathing the closed lids with cold water, and will usually subside within half an hour; and the application may at first be repeated daily. Under its influence it will be found that the discomfort, and any redness which may be visible in the naturally open condition of the lids, will diminish day by day and quickly disappear; but the redness will still linger in the lower palpebral fold, and the granulations will still be there. Under the continued application of the lapis, at first on alternate days and afterwards with still longer intervals, a healthy action will be set up in the conjunctiva, and the abnormal lymph-masses will gradually disappear by a process of interstitial disintegration or absorption, leaving no visible traces of their former presence, and no diminution in the natural softness and elasticity of the membrane. The time required for this process of restoration will vary according to the number and development of the follicular granulations, to the amount of irritation already excited either by their presence or by some external cause, and to the health and general condition of the patient; but, unless some of these elements in the case are unusually unfavorable, an ultimately successful issue may always be confidently predicted. The various complications which may arise during the course of the treatment, and the results they may severally produce, are practically the same as in acute conjunctivitis; and it will save unnecessary repetitions to consider them under that head.

In the treatment of a case of actual conjunctivitis, it is first of all necessary to ascertain that the disease is not due to the presence of a foreign body, and the next point is to observe whether the inflammation shows any tendency either to spread to the cornea or to interfere with its nutrition. In very acute forms of the disease, with much swelling of the lids and profuse purulent discharge, the ocular conjunctiva soon participates in the morbid action, and is elevated from the sclerotic by effusion between the two membranes. At the corneal margin, however, the effusion finds a barrier, and hence the conjunctiva is raised up all around the cornea, and may even overlap it with a swollen and congested margin. This state is called chemosis, and, in proportion to the degree of its development and to the firmness of the effused material, it threatens the life of the corneal tissue by arrest of its nutrition, and sometimes produces a very rapid sloughing or necrosis, which

is not preceded by inflammation. In other cases, less severe in degree, there is an early tendency to the development of a vascular keratitis; and fine twigs and loops of newly formed vessels may be seen encroaching upon the cornea, especially at its upper and lower portions. In others, again, there is a tendency to corneal ulceration of an inflammatory character, the first evidence of which is usually furnished by irregularity, roughness, and dulness of the epithelium at the margin. All these conditions of the cornea require separate consideration; but when they are absent, when the swelling of the lids is not excessive, and when the corneal epithelium is bright and undisturbed, then the treatment resolves itself into the employment of metallic astringents. Between the various forms which may be selected there is perhaps not much to choose; but, as regards pure conjunctivitis, some of the preparations of lead are probably more quickly efficacious than those of any other metal. They labor under the disadvantage of being absolutely inapplicable if there is any loss of corneal epithelium, because they are then liable to leave behind an opaque deposit of white carbonate, very firmly adherent to the corneal tissue. It not unfrequently happens that this result is produced when the remains of a lead lotion, carefully preserved by a patient whose conjunctivitis it has cured, are presented by him as a specific to some friend suffering from eye disease of a different kind. In hospitals or institutions, however, where there is adequate medical supervision, lead may be freely used in suitable cases. A solution of the acetate in distilled water, in the proportion of one grain to a drachm, furnishes a convenient formula; and this solution may be applied with a camel's-hair pencil to the surfaces of the everted lids. Before the lids are replaced the lotion may be washed away with another pencil and clean water; and the washing may either follow the application immediately, or after an interval of a few seconds, according to the degree of effect which it is desired to produce. The smarting and irritation which immediately follow may be subdued by the application of cold water, and the lead lotion may be repeated about every four hours, or after longer intervals as soon as improvement is declared. Dr. Schoenfeld has lately spoken very highly of the tannate of lead as a local application. This salt is difficult to triturate in a dry mortar, and Dr. Schoenfeld directs it to be rubbed down with a little almond or olive oil, and then to be made into an ointment by the addition of lard. His formula is: tannate of lead, one part and a half; fine oil, three parts. Rub together with great care, and add one part of well-washed fresh lard. Of this ointment, a portion the size of a barley-corn may be inserted under either lid. A lotion of sulphate or chloride of zinc, or of nitrate of silver, as already mentioned, may be employed instead of lead when the latter is for any reason contraindicated; or the sulphate of copper may be applied in the form of lapis divinus [or pure, in the form of a smooth crayon made from a crystal]. In some instances it will be found desirable to vary the astringent from time to time,

care being always taken not to select one of too active a character, and to limit its operation as far as possible to the eyelids and the palpebral folds.

In the obviously contagious forms of conjunctivitis, with profuse purulent discharge and early and considerable swelling of the membrane, it is found that the stronger astringents are not well borne at the commencement of the disease, and that sedatives are first required. It was in such cases that Von Graefe strongly recommended the application of liquor chlori, as a step towards astringents of a more active character; and this remedy is believed to have the incidental advantage of destroying the infective quality of the secretion. He directed it to be dropped into the eyes once or twice daily, and the results of its employment to be watched with the greatest care. If the conjunctival swelling showed any tendency to become more dense, and, as it were, brawny, or if there were symptoms threatening the spreading of inflammation to the cornea, such as increasing subconjunctival injection, an unusual degree of pain, spasm of the sphincter pupillæ (shown by the rapid subsidence of atropine dilatation), or irregularities of epithelium near the corneal margin, in any of these cases even the liquor chlori was to be laid aside in favor of soothing applications. If, on the contrary, the conjunctival swelling became more lax and voluminous, and the secretion more abundant and more purulent in character, then the liquor chlori should be superseded by the diluted solid nitrate of silver; and this in its turn, as the condition of the patient improved, by the milder salts of lead, copper, or zinc.

The application of solid nitrate of silver, diluted with from two to four parts of nitrate of potash and fused into a stick, is to be managed in the same way as that of lapis divinus, with the additional precaution that the everted lids should be washed with a solution of common salt, to neutralize any free caustic, and then with water, before they are replaced. The cases in which nitrate of silver is required are all of a dangerous character; and its accidental contact with the cornea might be followed by disastrous consequences. The immediate pain of the application is often severe, and the swollen and slippery lids are apt to escape from the fingers of the surgeon, and to return to their natural position before his washing away of all superfluous nitrate is completed. For these reasons, it is often desirable to render the patient quiescent by an anæsthetic; and to hold the everted lids by slightly toothed forceps, from which they are not likely to get free. The object of the cauterization is to procure an eschar of the epithelium only, and great care must be taken that the action does not penetrate to the basement membrane, so as to effect destruction of its continuity. Such destruction would produce cicatrices of the most injurious character, or even eventual adhesions between the eyelids and the globe. In order to avoid these consequences, the stick of diluted caustic must be applied very lightly and quickly, and the more so the greater its strength; while, if a diluted stick

should not be at hand, the pure nitrate can never be safely substituted for it. In such case a solution must be employed, varying in strength from two to ten grains to the ounce; and if its strength exceed four grains it should be applied by a brush and then neutralized by a solution of salt. The lotion of two or four grains to the ounce, which is so valuable in the purulent ophthalmia of infancy, may be dropped between the lids with no other precaution than first to wash away the discharge, so that the remedy may have free access to the conjunctival surface. The repetition of nitrate of silver must be governed by the intensity of the inflammation and by the effect produced. A lotion of two grains to the ounce may be applied every four hours; but an application which produces an epithelial eschar should not be repeated until that eschar has been cast off. This will happen the more quickly the more severe the case, but seldom in a shorter period than eight hours. As a general rule, even in the worst cases, it will be sufficient to apply the diluted solid nitrate at intervals of twelve hours, and as soon as improvement is manifest to use it only once daily, substituting some simple astringent for the second cauterization.

The soothing applications which are indicated in the earliest stages of acute contagious ophthalmia, or when the cornea is threatened by acute inflammation, may be of various kinds. Atropine should always be dropped between the lids twice or thrice daily, in the form of a solution of two grains of the neutral sulphate to an ounce of distilled water. Beyond this there is a wide range of choice among various compresses or fomentations, hot, cold, or tepid, and either medicated or simply moistened with water. It must be borne in mind that the general tendency of local heat is to increase vascular action, and that the general tendency of local cold is to diminish it. Sir Henry Holland long ago laid down the sound doctrine that the temperature of applications is a point on which a patient may be suffered to judge for himself; and in any case of doubt the question should be decided in favor of that temperature which affords the greatest degree of comfort. Dr. Warlomont strongly advocates the use of a lotion which he calls his brown wash, which is composed of a drachm of extract of henbane, two drachms of borax, and seven ounces of decoction of marshmallow. In use, the bottle is shaken, some of the lotion is poured out into a cup and warmed, and a linen compress of eight folds, steeped in it, is placed over the closed lids. This compress is to be changed now and then, so as to maintain the temperature, and the application is to be continued twenty or thirty minutes, and then laid aside for two hours, during which time it may be replaced by a wool pad and a light bandage. When dilatation of the pupil is desired, extract of belladonna may be substituted for the henbane.[1] Poppy and chamomile fomentations would be likely to commend themselves to English practitioners; and, whatever form of moisture may be employed, it will be well to

[1] [Hyoscyamus, and datura also, have the power of dilating the pupil.]

preserve the delicate skin of the eyelids from irritation, by anointing them with simple ointment or with olive or almond oil.

[Cold wet compresses, and especially iced compresses, are held by most practitioners to be essential to the proper treatment of the early stage of acute purulent ophthalmia, and especially of gonorrhœal ophthalmia. Several compresses of soft linen, folded twice, are kept upon a large lump of ice in a basin near the patient's head, and a fresh one is applied to the closed eyelids as soon as the former one has become at all heated. This may be as often as once in a minute or two minutes, if the elevation of temperature is very great. In cases of less severity it is sufficient to wet the compresses in water kept cool by a piece of ice floating in it.]

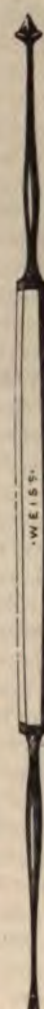
Bearing in mind, then, that it is impossible to draw any line of demarcation between the mildest form of conjunctivitis and the most severe purulent ophthalmia, and that the successful treatment of each case will depend upon a correct appreciation of its stage and its tendencies, and upon accurate and enlightened observation of the effects of the first remedies selected, it may be laid down as a general principle that all mild forms will bear mild metallic astringents from the beginning, and will often be readily cured by them. The more severe forms display an early period of acute irritation in which any stimulation would be mischievous, and would increase the severity of the attack. This period must be tided over by the local use of atropine and sedatives, aided by such regimen and general treatment as the state of the health may require. It may lead either to a brawny swelling of the conjunctiva, with thin discharge and a tendency to corneal death or inflammation, or to a voluminous and lax swelling, with discharge of a purulent character. The former condition, when of a pronounced kind, precludes the use of local stimulation; the latter requires the repeated destruction of the epithelium by caustics. Between them the surgeon must feel his way with liquor chlori and astringents, knowing that the premature or excessive use of the latter may destroy the cornea, and that improper delay in their application may not only allow the disease to pass into a stage of obstinate chronicity, but may also allow the conjunctiva to become covered with papillary granulations which will be fertile sources of future mischief. At either extremity of the scale the treatment to be pursued will not admit of doubt; but in cases which fluctuate from day to day, leaning sometimes towards one character and sometimes towards the other, the skill and judgment of the surgeon will be heavily and continuously taxed.

When any form of severe conjunctivitis appears in one eye only, there is, of course, great danger that the other may be inoculated by the discharge, which, if profuse, may even flow over the bridge of the nose and into the other eye during sleep. One of the first duties of the attendant is to guard against the occurrence of such an accident; and for this purpose it was formerly customary to close the sound eye by a waterproof compress, cemented to the skin by collodion and retained by a bandage. A better method has lately been introduced at the Royal London Ophthalmic Hos-

pital, by covering the sound eye with a watch-glass inserted into a shield of waterproof plaster, which is fixed to the forehead and nose, but left free on the temple and cheek, so as to afford to the patient at once sight and ventilation.[1] If the materials for this contrivance are not at hand, the old form of bandage should be employed It is unjustifiable to leave the healthy eye unprotected even for an hour.

The first dangers threatened by the more severe forms of acute conjunctivitis are necrosis or ulceration of the cornea, either wholly or in part; and the first symptom that either danger is impending is afforded by turbidity of the centre, or by inequality of the epithelium at the marginal parts of the membrane. Such appearances must not interfere with the otherwise indicated application of nitrate of silver to the conjunctiva; but they demand the most scrupulous care that the cornea itself may not be touched by the caustic. Together with the cauterization, atropine must be dropped between the lids, and deep scarification of the conjunctiva may often be practiced with advantage. If perforation should threaten, it may sometimes be prevented by careful paracentesis of the anterior chamber. The puncture may be made with a broad cutting needle, at the very margin of the cornea, and the wound should be reopened with a probe at regular intervals, so as to allow the aqueous humor to escape, and to relieve the weakened part of the cornea from the intra-ocular pressure. A convenient needle for paracentesis, shown at Fig. 65, is sold by instrument-makers. It has a stop to arrest its penetration, so that it cannot wound the iris or lens, and a probe for opening the puncture is mounted at the other extremity of the handle. If perforation should occur, and the loss of substance be at all large, the case usually terminates either in total staphyloma or in phthisis bulbi; and, even if the loss is only small, the cornea is often so much flattened or distorted by the healing process as to render the eye of little value for purposes of vision.

FIG. 65.



Ulcers which do not perforate require no special treatment until they begin to refill and heal. During their earlier stages the cauterization or milder stimulation indicated by the state of the conjunctiva must be sedulously carried out, and atropine must also be employed. As soon as a process of repair commences it may be promoted by various local applications, which must not interfere with those required by the conjunctiva Among them, the first place may be given to Pagenstecher's yellow oxide of mercury ointment; and if this ceases to act beneficially there are one or two analogous preparations by which it may be replaced. Dr. Williams's citrine ointment may be tried, in which olive oil is replaced by cod-liver oil, or one of the following: ℞. Hydrarg. ox. rub., gr. iss.; Adipis, ʒj; Bals.

[1] [This is substantially a rather old device of Snellen.]

Peruv., gtt. x; M. ft. unguentum; or ℞. Arsenici sulphureti, gr. ij; Ung. Hydrarg. nitratis, ʒij; Adipis ʒvj; M. ft. unguentum.

[Dry calomel, in impalpable powder, dusted in very minute quantity into the eye once a day, is a highly valued remedy in the healing stage of corneal ulcers, and especially in phlyctenular keratitis and in superficial inflammation of the cornea with thickening and opacity of its epithelial layer. Pagenstecher's ointment of yellow oxide of mercury (gr. x or xxx ad ℥j) answers well in cases which require a stronger stimulation, and we think it should wholly supersede the coarser and harsher red precipitate (*Hydrargyri oxidum rubrum*). Dr. Williams's citrine ointment differs from the officinal preparation chiefly in the fact that the reaction of the mercurial salt upon the fat is completed, and all free nitrous compounds expelled, by keeping the newly made ointment for several hours at the temperature of a hot-water bath. We incline to the opinion that it is not in any way the equivalent of the officinal ointment.]

A small portion of any of the foregoing may be placed within the lids once in twenty-four hours. When healing is complete, and if the resulting cicatrix interferes with vision, an artificial pupil may be made by means of a small iridectomy behind a clear portion of the cornea; and if the cicatrix be unsightly it may be concealed by being tattooed with Indian ink in a manner hereafter to be described. This, however, must not be done for fully six months after its formation.

When the cornea has escaped serious mischief, the subsidence of the acute stage of the disease may either lead to perfect recovery, or to a state of chronic inflammation, in which there is great liability to frequent relapses, and a tendency to hyperplasia which shows itself in an exuberant crop of papillary granulations. The inner aspects of the eyelids are villous over their whole extent, the palpebral folds hypertrophied, and almost shaggy with enlarged and vascular papillæ. In process of time the tendency to relapse dies out; but the papillæ remain and may assume almost a warty appearance, while the subconjunctival tissue becomes thickened and indurated. Such a state occasions the development of vessels beneath the corneal epithelium; and these vessels are sometimes so numerous and so closely set that they produce opacity and loss of sight. For the prevention of such a state of things the stage of improvement from the acute attack requires to be carefully watched, and the application of nitrate of silver must be regularly made for some time after the violence of the disease is exhausted. When the nitrate is at last laid aside, it must be replaced by the long-continued use of some milder application, as by a lotion containing a salt of zinc, or lead, or copper; or sometimes the lapis divinus may be preferred. The presence of chronic granulations, and of vascularity of the cornea arising from them, may be ascribed, almost always, to neglect during the periods of improvement and convalescence, and to the too early abandonment of local treatment.

Even when chronic granulations are established and of old date it will often happen that much may be done for them by the persevering use of lapis divinus, applied to the lids daily or on alternate days; and as the granulations diminish the vascularity of the cornea will diminish also, and great improvement of sight may be obtained. The lapis may now and then be replaced for a time by some other astringent, such as acetate of lead or tannin, and the application of the acetate in fine powder has been recommended by many writers. If there is any clear portion of cornea, an artificial pupil may perhaps be made with advantage. When, however, the vascular network over the cornea is very close, constituting the condition called "pannus," there is little to be hoped for from anything short of a second attack of purulent ophthalmia, to obtain which inoculation from the eye of an infant may be practiced. The cornea is protected from sloughing by its vascular character, and the inoculated disease may be suffered to run its course unchecked. After its subsidence, the cornea will frequently clear in a very remarkable manner.

In cases where the chronic papillary granulations are not sufficient to produce great impairment of vision, where they vascularize only the upper margin of the cornea, and lie themselves concealed and unnoticed under the lid, they undergo in process of time a gradual degeneration or cicatricial shrinking. In this way is produced the increased convexity of the upper tarsal cartilage by which the cilia are so often turned inwards upon the eye.[1] The cases of chronic trichiasis which frequent our hospitals have nearly always this history. The tarsal cartilages are shortened, thickened, and incurved; and, on everting the lids, are seen to be crossed by dense lines which resemble the contracted cicatrix of a burn.

The history of contagious ophthalmia in a pauper school is usually that the disease has been introduced in some accidental manner, probably by a new inmate, whose conjunctivitis escaped observation and quarantine. It would find a large proportion of the children with follicular granulations, the result of insanitary conditions, some of which were perhaps unavoidable. I do not believe that these follicular granulations are themselves an actual cause of ophthalmia; but they certainly entail a greatly increased proclivity to contract it, and a tendency to the development of its severer forms. It is well established that the eyes in which they exist are less amenable than others to the beneficial action of the stronger astringents, and that they require to be dealt with very tenderly and cautiously. The surgeon to the school may not at first fully appreciate the gravity of the crisis with which he has to deal, or he may not have enjoyed sufficient opportunities of studying diseases of the eye to be perfectly conversant with all the conditions which should guide his treatment. One child after

[1] [We have already expressed the opinion (see page 185) that this change is due mainly to the follicular (trachomatous) form of granulations.]

another goes into the infirmary with "bad eyes;" and the cases increase in number and severity week by week. At first, it has often happened that some undiscriminating plan of treatment has been adopted, and that its application has been intrusted to some careless or incompetent person. Under such circumstances the bad cases go wrong; and the mild cases are discharged from the infirmary half-cured, with mischief still lurking in their palpebral folds, to spread disease among their playmates, and themselves to undergo relapse. Matters proceed from bad to worse; the whole establishment becomes saturated with contagium, nurses and helpers suffer, many eyes are lost, and a public scandal is created. Then, at last, a specialist is called in; and is too often asked to banish the epidemic, notwithstanding the continued existence of all the causes which have fostered and perpetuated it.

The first duty of a consultant, in such a case, would be to examine the eyes of every child in the institution, to classify the inmates in such a way as to separate the diseased from the healthy, and to divide the former into groups for treatment, each group containing cases as nearly as possible of the same type. He would thus acquire an exact idea of the extent and characters of the evil with which he had to deal.

The next step would be to proceed to the systematic disinfection of the building and its contents. Bearing in mind the possibility of contagion from floating fungus spores, it seems that sulphur fumigation should be first employed, followed by thorough washing and ventilation. This work must usually, of course, be done in sections; and it would be desirable that the sections should correspond, as nearly as possible, with the groups into which the inmates were divided. The washing arrangements should next be so modified that personal contact between children should be avoided; and that the whole process should be conducted in an orderly manner, and under constant supervision. Each child should receive a dry towel from the attendant in charge, and should restore it to him when done with; and these towels, instead of being placed damp in the dormitories, should be at once dried in a hot closet, at a sufficient temperature to destroy the infectious character of any discharge which may have soiled them.[1] The ventilation of the dormitories should be carefully provided for, not only by a cubic space much in excess of that now required by authority, but also by a rule that cubic space should rest upon a proper extent of floor area, so that beds should not be crowded together in a room lofty out of proportion to its other dimensions. At the same time especial care should be given to the ventilation;

[1] [The best washing arrangement which we have seen is that by which each child washes his hands and face at a small jet of water. A water pipe running along the wall of the washroom is tapped with a large number of these jets, and the water is carried off by a long sink or trough. Each child has his own towel, which he hangs upon a numbered hook after using it; washing appliances are wholly excluded from the dormitories.]

and the use of the vertically ascending air currents, lately introduced by Mr. Tobin, should in most cases be strenuously recommended.

The medical treatment of the patients would rest mainly upon careful classification of their cases, upon the exercise of due discrimination in moving them from one class into another, upon the proper selection, application, and neutralization of the necessary caustics and astringents, and upon constant watchfulness that no application of this kind was repeated if it were causing too much irritation, or continued after it had ceased to stimulate beneficially. It should be an absolute rule that nitrate of silver should never be applied by any non-medical person, and that the other local remedies should be placed in no hands less trustworthy than those of a skilful, attentive, and experienced nurse, who has first been thoroughly instructed in the manner of so using them that the cornea may escape uninjured. The practice of discharging children as "cured," before the cure is complete, either from undue anxiety to make a good show upon paper, or from negligently overlooking mischief still lurking in the palpebral folds, should, of course, be strictly guarded against; and the general health of each inmate should receive individual attention, and should be improved or maintained by suitable food, medicine, exercise, and manner of life. That communication between the sick and the healthy should be absolutely prevented, that communication between patients in different stages of the disease should be restrained, and that all new inmates should undergo a period of quarantine and a careful inspection, are precautions so obvious that it is not necessary to enlarge upon them. By the employment of the means thus briefly indicated it would in most cases be possible to free a school or similar establishment from ophthalmia in the course of three or four months; unless the overcrowding of the inmates, or some other insanitary condition maintained by official authority, were sufficient to neutralize in some important particular the good which would otherwise be secured.

In every epidemic of conjunctivitis it is usual to meet with a few cases in which the discharge, instead of being purulent, is coherent or fibrinous, so that it can be seized by forceps and peeled off in larger or smaller pieces, leaving a bright-red surface below. This fibrinous exudation is soon renewed after removal; and the cases in which it occurs present no other special peculiarity, and call for no modification of treatment. They have, however, by some English writers, been described as "diphtheritic," a term which is highly objectionable on two distinct grounds. In the first place the patients are not the subjects of diphtheria, or of anything very much like it; for the resemblance between the coherent or fibrinous pus and true diphtheritic exudation is only superficial. Next, the word diphtheritic is already in general use to denote a form of conjunctivitis which is not uncommon among poor children in Germany, and is especially prevalent in Berlin, but which

is, I believe, wholly unknown in England.[1] In this, the diphtheritic conjunctivitis of German writers, the fibrinous effusion does not occur on the conjunctival surfaces, but in the interstices of the subconjunctival tissue. The prominent symptoms are great pain, heat, and swelling of the eyelids, with distension of the subconjunctival tissue by a pale, firm, brawny effusion, which arrests the local circulation and threatens the cornea with speedy destruction by necrosis. It is unnecessary to dwell upon the treatment of an affection which is little likely to be met with here, and which has been much studied in the country in which it chiefly prevails.

The only other form of inflammation of the conjunctiva that requires notice is the phlyctenular ophthalmia, often miscalled conjunctival herpes, and thus sometimes confounded with the true herpes which depends upon changes in the corresponding Gasserian ganglion, and which attacks chiefly the cornea. In phlyctenular conjunctivitis (which occurs chiefly in children), the surface of the eyeball presents one or more small elevations or "phlyctenulæ" each situated in the midst of a patch of congestion. They probably commence in the same way as follicular granulations, by the undue aggregation of lymph-cells in the meshes of connective tissue, and excite inflammation by their pressure upon surrounding parts. Each phlyctenula runs its course in about eight days. The elevation throws out fluid at its summit, and becomes a pellucid vesicle, which bursts and forms a small ulcer, the floor of which is covered by a tenacious film of buff-colored material. This undergoes disintegration and is cast off, and then the ulcer heals. The phlyctenulæ may be either single or multiple, and they often appear in successive crops. The formation of each vesicle is attended with some burning or stinging pain, which subsides when rupture has taken place, and is succeeded only by such sensations of itching or discomfort as may be due to the amount of attendant conjunctivitis. Phlyctenulæ may occur on the cornea, in which position they will be referred to in a future chapter; but their most common seat is on the ocular conjunctiva, just beyond the corneal margin. A single one hardly requires any other treatment than rest of the affected eye and protection from dust, heat or cold, and glare; but recurrent phlyctenulæ point to some disorder of the general nutrition, and often to something faulty in the habits of life, or else to some unfairness in the conditions under which the eyes are called upon to work. The surgeon should examine into the state of the health, into the acuteness of vision and the state of the refraction, and into the habits with regard to study, diet, and exercise; and should endeavor to correct whatever among these may be at fault. If he finds no other indication it is generally advisable to give bromide of potas-

[1] [Diphtheritic ophthalmia occurs occasionally in New York city and vicinity, and doubtless in other parts of the United States. We have seen but one case, and that not very well-marked, in St. Louis.]

sium, either with or without ammonio-citrate of iron. In the way of local treatment he must be guided by the amount of conjunctival hyperæmia or inflammation, which will depend, other things being equal, upon the number of vesicles that are formed at or about the same time. Any mild astringent lotion will generally meet the circumstances of the case; and the healing of the little ulcers may be promoted by dusting them with dry calomel, or by the daily application of Pagenstecher's ointment.

The conjunctiva may be the seat of morbid growths of various kinds; among which I have met with dermoid and sarcomatous tumors, the former sometimes bearing hairs. Such growths may be pinched up and removed by scissors, and it is usually desirable to unite the edges of the incision by a point of suture. If the wound is large, the conjunctiva should be dissected up from the sclerotic for a short distance on either side; and it will then come together readily. It is not uncommon to see subconjunctival collections of fat, or of yellow fibrous tissue; and these, which are mostly situated on either side of the cornea, are apt to be nipped and moulded by the closure of the lids, and to form little tumors, sometimes almost pedunculated, on the horizontal meridian. Such growths are harmless, but sometimes unsightly; and I have more than once excised them with good effect. Another form of conjunctival growth is pterygium, which consists of hypertrophy of tissue, sometimes very trifling in amount, sometimes very considerable, having a generally triangular outline, with its apex trespassing more or less upon the cornea. Pterygium is usually a result of long-continued inflammation; and is scarcely at all amenable to treatment. The hypertrophied material may be removed by excision or ligature, but the same kind of action is often renewed in the cicatrix, and the patient seldom derives material or lasting benefit from any operation. A pterygium does no harm unless it extends so far over the cornea as to obstruct vision; and then the best course is to enlarge the pupil by iridectomy.

[Arlt, who is one of the highest authorities in ophthalmic surgery, states positively that pterygium does not usually return when the operation has been rightly performed. The whole mass of the pterygium is seized at its neck (that is at the sclero-corneal junction) by a pair of toothed fixation forceps (Fig. 41. p. 150), and the head or corneal portion is cleanly dissected off from the cornea by means of a bent lance-knife (Fig. 44, p. 155); two convergent cuts are then made from the upper and lower extremities of the first wound towards the inner angle of the eye, and the isolated flap of tissue is cleanly dissected from the sclera for about one-third of an inch from the corneal margin. This isolated flap, consisting of the vascular tissue of the pterygium, is not cut away, but is left to shrivel up towards its attached border, at or near the place of the semilunar fold, and the exposed surface of the sclera is covered in by drawing the conjunctiva together by a single suture placed from one-eighth to one-fifth of an inch from

the corneal margin, according as a smaller or larger portion of tissue has been removed. We have had occasion to try most of the known operative methods, whether by excision, transplantation, or ligature, and have settled upon Arlt's operation, substantially as here described, as by far the most satisfactory. The essential points are to cut away as little tissue as possible, to dissect up the growth cleanly from the cornea and sclera, and to close the conjunctival wound with a suture.

In this chapter, upon the diseases of the conjunctiva, the author lays less stress than is usual upon their classification. Whatever may be our convictions regarding the pathological unity of the several forms and grades of ophthalmia, it is none the less useful to subdivide them according to their well-marked etiological and clinical differences. It has seemed proper, therefore, to give here a brief synopsis of the usual classification of the ophthalmiæ, as found substantially in all the systematic works on the diseases of the eye.

According to the degree of the inflammatory process, we may distinguish—

First. Hyperæmia of the conjunctiva.

Secondly. Catarrhal ophthalmia, marked by swelling of the conjunctiva and increased secretion of mucus mixed with exfoliated epithelium and perhaps a little pus.

Thirdly Purulent ophthalmia, in which the swelling of the conjunctiva is greater than in the catarrhal grade, and in which the discharge, at first serous, becomes distinctly purulent.

Between these three grades there is no clearly drawn line of demarcation; nevertheless, as a rule, they are distinct in their origin, tendencies, and indications for treatment.

Conjunctival hyperæmia is ordinarily the result of irritation from mechanical or chemical causes; it tends, as a rule, to get well of itself, and calls for no treatment further than rest, protection from the action of irritating agencies, and, in some cases, the occasional instillation of a weak solution of atropia to control irritability. If neglected, or aggravated by improper exposure, it may lead to granular disease of the eyelids, and ultimately to loss of sight from corneal complications.

Catarrhal ophthalmia commonly originates from "taking cold," or by contagion from a non-virulent source, such as a catarrhal ophthalmia in another member of the same family. Its tendency, also, is toward recovery, under the use of simple antiphlogistic applications conjoined with rest and protection from all sources of irritation. Such cases bear well, almost from the beginning, and generally improve rapidly under the use of mild metallic astringents, such as the solution of nitrate of silver (gr. ij ad ℥j), as recommended in the text. Left wholly to itself, catarrhal conjunctivitis is often rather tedious in its progress toward recovery, and is very apt to become chronic, leading to a granular condition of the lids with its train of disastrous consequences. A neglected

case of catarrhal ophthalmia is also a constant source of danger to others from contagion.

Purulent ophthalmia may be only an aggravated catarrhal ophthalmia, but is more frequently the result of the direct inoculation of matter from some virulent source, such as the discharge from the inflamed urethra or vagina, or from another eye similarly diseased. It is attended by conspicuous swelling of the conjunctiva and eyelids, with discharge, at first, of serous or somewhat blood-stained fluid, and, later, of pus, generally in large quantity. It is essentially an acute affection, often working destruction very early in its course, and demanding prompt, efficient, and well-directed treatment. In the beginning it does not bear irritant or astringent applications of any kind, but must be treated in a purely antiphlogistic way by rest, cold (iced) compresses, constantly renewed, atropia solution once or twice a day, and, in case of great swelling of the conjunctiva or eyelids, division of the external canthus and external canthal ligament. (See page 196.) In cases of less severity a few leeches may be applied to the temple, about an inch behind the outer angle of the eye. Later in the disease, after the discharge has become purulent, mild metallic astringent collyria are to be tried, and, if well borne, stronger nitrate of silver solutions (gr. v or x ad ℥j), or the mitigated nitrate of silver stick should be applied to the conjunctival surface of the eyelids, washing it off, after a few seconds, with a soft brush dipped in salt water.

In conjunctivitis, if we regard the especial types of the disease, we may distinguish—

First. Simple conjunctivitis, marked by papillary engorgement or hypertrophy—"papillary granulations."

Secondly. Trachoma, or follicular disease of the conjunctiva—"follicular granulations."

These forms may exist separately, but they very often occur together, one type or the other usually predominating; or one type may predominate in the earlier, and the other in the later stages of the same case. We constantly meet with cases of simple catarrh, in which the continuing hyperæmia is attended by the gradual development of trachoma granules; and, on the other hand, we know that trachoma "sago-grain" granulations may occur independently of inflammatory symptoms, and, not infrequently (in charity schools, etc., perhaps almost constantly), may exist for a long time prior to any outbreak of active inflammation.

Thirdly. Phlyctenular or eruptive conjunctivitis, which may occur either in a pure form or conjoined with general conjunctival inflammation, usual catarrhal.

The ophthalmia of newborn children may conveniently be considered by itself; it is of the type of simple conjunctivitis, marked by papillary engorgement or hypertrophy, and occurs of all grades, from conjunctival hyperæmia, conjoined with slight hypersecretion of mucus, to a virulent type of blennorrhœa. In view of these vast differences in degree it is difficult to resist the conviction

that they depend upon corresponding differences in causation, and that the disease is in many cases the direct result of the inoculation of vaginal discharges, which may vary in virulence from that of the mildest leucorrhœa to that of a virulent gonorrhœa.

Finally, as connected with defective sanitary conditions, or with special epidemic tendencies, it is important to distinguish such forms as the Egyptian ophthalmia, the ophthalmia of barracks, orphan asylums, etc., and especially the croupous and diphtheritic forms.]

CHAPTER VIII.

DISEASES OF THE CORNEA.

THAT the cornea should be transparent, at least over a great part of its extent, and that the curvatures of this transparent part should be normal in all directions, or should depart from the normal standard only within the limits of correction by optical appliances, are two conditions essential to the exercise of useful vision. They are conditions, moreover, which most of the diseases of the cornea tend to modify, or even to subvert. Inflammation produces turbidity, either superficial or interstitial, more or less complete in degree, and more or less permanent in character; while, by softening the texture of the membrane, it prepares it to yield to any increase of tension from within, and to become unnaturally prominent or globose. Ulceration produces losses of substance which are made good, at the best, by opaque cicatricial tissue [leucoma]; and the contraction incidental to the healing process often produces marked flattening of the surface. Impaired nutrition, or atrophy, being usually most advanced in the centre, where the blood-supply is most remote, causes the thin and enfeebled central portion to project, under the pressure of the contents of the eyeball, and to form the somewhat pointed elevation which is known as conical cornea. Superficial clouds [nebulæ], the result of changes in the external epithelium, may be completely removed in course of time; but the opacities left behind by loss of true corneal structure are essentially permanent, although they may undergo some apparent diminution by the disappearance of superficial turbidity surrounding them, and some actual diminution by the gradual contraction of the cicatrix. Interstitial turbidity produced by inflammation, if not absolutely permanent, is at least extremely intractable; in the worst cases resisting all treatment,

in the most favorable clearing only very slowly, and leaving behind some degree of residual dulness. It follows that in all affections of the cornea the active continuance of any morbid process, even for a short period, may inflict irreparable injury. An ulcer which to-day is small and eccentric, may to-morrow so extend itself as to produce permanent opacity in front of the pupil; and an inflammation which at first is only marginal, may before long spread over the whole surface. Hence we should in all cases endeavor to arrest impending corneal troubles at the earliest possible time; and in like manner, when they are no longer only impending, but declared, we should strive to hasten forward the commencement of resolution or repair. For these purposes, and in addition to the fulfilment of general indications, the surgeon should aim at attaining perfect mastery of all the resources of local treatment; so that he may neither do harm by unsuitable applications, nor withhold any advantages which suitable ones might afford.

Some of the most formidable of the affections of the cornea are those which arise during the course of severe conjunctivitis, or which are produced by the gradual operation of the changes which conjunctivitis may leave behind. In the purulent ophthalmia of infancy simple necrosis of the cornea is the only complication which need be dreaded, or which interferes with complete recovery; and it occurs in a large proportion of the cases which are neglected in their earlier stages. It always commences in the centre of the cornea, or nearly so; and appears to depend upon the arrest of nutritive changes by the contiguous inflammation. When a case of infantile purulent ophthalmia has been left for some days without treatment, or has been treated imperfectly, the centre of the cornea is often found hazy or turbid; and this turbidity may go on to rapid disintegration of tissue. If the destruction is arrested prior to actual perforation, a cicatrix will be left of size and density corresponding to the extent and depth of the corneal slough, and affecting vision, more or less, according to these circumstances, and also according to the exact position of the cicatrix, and its relations to the pupil. If perforation takes place, the destructive process is usually arrested; and the opening through the cornea, if of very small size, may be effectually plugged by adhesion of the iris. In such cases partial recovery may follow, the adhesion of the iris being permanent, the pupil being more or less tied down behind the opacity, and the cicatrix, which is fed by the vessels of the iris, having scarcely any tendency to be thinned or removed by subsequent changes. When the perforation is large, the iris may fill it in the same manner; but the base of the ulcer thus formed is too weak to resist the intraocular pressure, and soon begins to bulge beyond the level of the cornea and to form what is known as a partial staphyloma. If the slough has been large and central, including nearly the whole of the cornea, and exposing not only the iris but also the anterior capsule of the lens through the pupillary opening, these structures become covered and united

together by effused lymph, which ultimately forms a smooth and semi-transparent surface to the prominent cicatrix, and allows the color of the iris to be seen beneath. The total staphyloma thus formed has sometimes been mistaken for a turbid cornea; but it really consists of new tissue to which the iris is adherent; and however good may be the perception of light, such cases do not admit of any treatment, either operative or medical. When the slough has been smaller, the staphyloma may be surrounded by an annulus of true corneal tissue, and by a space containing aqueous humor; and then, especially if the ulcer has been eccentric, this annulus may in some part be broad enough to permit the formation of an artificial pupil behind it. Even in the most promising of these cases, however, the curvatures of the remaining portion of cornea are usually much altered, and the best result generally attainable is the conversion of a blind eye into one which possesses very imperfect vision. If both eyes are affected, even such a degree of success may be a great boon to the patient; and if only one has suffered, its partial restoration is by no means to be despised. In considering sympathetic ophthalmia, we shall find good reason to regard a "blind side" as being oftentimes a source of serious danger.

The most successful treatment of cases in which the cornea has sloughed in infancy being thus only of comparatively small account, it is obvious that the prevention of corneal sloughing should engage the careful attention of the surgeon. Every one is acquainted with the facts and experiments which show that ulceration, or rather necrosis, of this membrane may occur as a result of inanition, without any previous inflammation either in the conjunctiva or elsewhere; and there can be no difficulty in conceding that the cornea of an infant will perish more readily—after a shorter period and less intense degree of conjunctivitis—if the infant itself is weakly or cachectic by inheritance, or has been improperly or insufficiently fed. But this concession, while it furnishes a reason why the eyes of such infants should be vigilantly watched, affords no excuse, according to my experience, for corneal sloughing under medical treatment. I have never seen a single instance in which the cornea has sustained injury if the treatment by cleanliness and nitrate of silver lotion, which is described at page 208, was commenced while it was still bright. I cannot deny that such instances may have occurred, but I have never met with one. Still, speaking from my own experience, I should say that a proclivity to corneal sloughing is induced by inherited syphilis more decidedly than by any other single cause; and next to this I should place badly managed hand-feeding. If the surgeon is called to a case, however acute the inflammation, however great the swelling, and however abundant the discharge, in which careful washing reveals transparent and polished corneæ, he may safely put his trust in the nitrate of silver lotion, if only it is properly applied; and he need not divert the minds of the attendants from this cardinal point by giving them more than general directions

about other matters. But if the cornea shows even the commencement of turbidity, inquiry must at once be made with regard to inherited syphilis, and with regard to the management of the feeding. If there is syphilis, it is necessary to have recourse to mercurial inunction. The conditions are too urgent, the dangers of delay are too great, to leave time for coquetry with chlorate of potash or other reputed remedies. If the mother's milk should appear to be either defective in quality or deficient in quantity, it is best to make immediate arrangements for obtaining a wet nurse; for, although feeding by hand may be so accomplished as fully to supply the requirements of infantile nutrition, the necessary management calls for more care, cleanliness, and minute attention to matters of detail than it is ordinarily possible to insure. Whatever method of feeding may be employed, it will usually be desirable to give also some medicinal tonic and nutriment; and for this purpose I generally employ the following formula: ℞. Olei morrhuæ, f℥ij; Mist. acaciæ, f℥iv; Liq. cinchonæ, ♏xxiv; Syrupi, f℥vss.; M. Capiat coch. j. min. ter die.

The local treatment pursued must be the same as for the uncomplicated forms of the disease, with the addition that when a central ulcer exists a drop of a weak solution of atropine should be put into the eye twice a day. From half a grain to a grain of the neutral sulphate, to an ounce of distilled water, will be a proper strength. By thus maintaining dilatation of the pupil, and keeping its margin away from the region of the ulcer, it may sometimes be possible to prevent the formation of adhesions between the iris and the cicatrix.

When a corneal slough is so extensive, or has made so much progress when first seen, that a total or a very large staphyloma is inevitable, the nitrate of silver lotion may still be used to expedite recovery from the conjunctival affection, and the above-mentioned constitutional remedies may also be required. But in such a case it is better at once to speak of the eye as a perished organ, which may, indeed, hereafter require surgical treatment to remove deformity, but which can never be useful for purposes of vision. On the other hand, when the slough is of such a size that a scar of something less than half the diameter of the cornea is likely to be the result, there is always a prospect that an artificial pupil may be made when cicatrization is complete. The formation of such a pupil may be attempted, however narrow the annulus of clear cornea, in every case in which this annulus is distinctly separated from the subjacent iris by a film of aqueous humor; and the operation should as a rule be performed early, for the following reasons. In the first place, defective vision in infancy, by depriving the eye of any definite object of fixation, deprives its external muscles of their natural stimulus to functional activity. The eye rolls vaguely about, instead of being always directed to some definite point; and the muscles never acquire the power of steady fixation. The result is the condition called nystagmus, in which the eyeballs are in perpetual oscillatory move-

ment; and this condition, once established, is generally irremediable. We often see cases in which the purulent ophthalmia of infancy has been followed only by superficial haziness of the cornea over the region of the pupil, and in which this haziness has cleared away in the first two or three years of life, but not quickly enough to prevent the production of nystagmus, which remains after the condition in which it had its origin has passed away. We should always endeavor, therefore, to give the infant sufficiently clear vision for the definite guidance of his eyes; and for this purpose should make an artificial pupil whenever there is a piece of clear cornea behind which it can be placed. It is useless to operate, at least on this ground, if the remaining cornea is even superficially turbid; because then, although it may become clear eventually, it will not become clear soon enough for the attainment of the end proposed. There is, however, another reason for operating, namely, that in natural tension of the eyeball a staphyloma tends constantly to increase its protrusion, yielding as the globe is acted upon or compressed by the muscles, and constantly taking up into itself more and more of the surrounding tissues. A large iridectomy, when practicable, will diminish the tendency to protrusion, and will therefore exert some degree of protective influence over the sight, especially if moderate compression of the eye can be maintained for a considerable time. The best way of effecting this is by a band of fine elastic webbing so adjusted as to retain an ordinary compress over the closed lids, and arranged with due regard to the tenderness of the cranium upon which its pressure is to be exerted. Such devices, however, although they may sometimes be rewarded by a certain measure of success, cannot be regarded very hopefully; and in many cases any remaining cornea is in such close apposition with the iris that an operation is hardly practicable. Even then, I have sometimes succeeded in snipping out a morsel of iris, so as to make a perforation which re-established an anterior chamber, and prepared the way for a more complete iridectomy at a future time. Anything is better, especially when both eyes are implicated, than to allow a staphyloma to complete itself unchecked, and to bring about the entire destruction of an organ which might in some degree have been saved. Still, as I have said already, the emergency is one which ought never to arise, and which certainly will not arise when judicious treatment has been properly carried into effect in the early stages of the malady.[1]

It will sometimes happen, when a case of purulent ophthalmia is first seen, that although there is no actual destruction of the corneal tissue, there may be considerable disturbance of its superficial layers, of such a character as to produce turbidity, which becomes very evident as the inflammation subsides, and which, although it may eventually disappear, may last long enough to be

[1] [We have already intimated that this statement appears to us to be somewhat too strong. See page 209.]

a cause of nystagmus. In such instances it is a manifest indication to hasten the disappearance of the turbidity; and for this purpose, not only in infants, but also in children and adults, I have derived great advantage from a plan which was suggested some years ago, I believe by Professor Rothmund of Munich, although I have never seen his original paper upon the subject. This plan is the subconjunctival injection of a solution of chloride of sodium. I use a solution of ten grains of common salt to an ounce of distilled water, and inject it with a hypodermic syringe, the point of which is pushed a little way between the conjunctiva and the sclerotic. I find that from five to ten minims may be injected at once, according to the degree of laxity of the conjunctiva; and the little operation may be repeated about every three weeks with manifest good effect. I have never seen it produce any reaction of an injurious character, and I have practiced it on patients at all periods of life, from infancy to middle age, for many times in succession.

The more severe forms of conjunctivitis which occur subsequently to the period of infancy are all of them liable to be sources of danger to the cornea in various ways, and primarily in the same way as the infantile variety, by producing sloughing or necrosis, followed, according to extent and degree, by opacities with or without adhesions of the iris, or by partial or complete staphyloma. The states which give rise to these conditions have been discussed in the preceding chapter, so that it is not necessary to return to them; and the same remark applies to the changes in the eyelids which conjunctivitis may leave behind, and which become causes of that superficial roughening and vascularization of the cornea, which, in its extreme degrees, is known as "pannus." Of this state it may fairly be said that each case, or even each eye, requires individual study. I have lately had under my care a discharged soldier, who was once so blind from pannus that he was led by the hand to the hospital, and whose right eye was somewhat worse than the left, the condition of the two, except for this slight difference of degree, being apparently identical. The right eye so far improved, in the course of about fifteen months, that the patient read No. 6 of Jäger's types easily, and could see to follow any ordinary occupation, in which condition he became an emigrant to New Zealand. The left eye was always treated in the same way as its fellow, and has been better and worse; but when the patient left England, it was very much in the same state as when I first saw it. The general principles which I have deduced from this and analogous cases are briefly that violent or strong applications are mischievous, that nitrate of silver in solid dilution, or crystal of sulphate of copper, does more harm than good, and that the best results are obtained from mild remedies[1]—such as nitrate of silver lotion, ranging from

[1] [The mitigated nitrate of silver stick, and the smooth crayon of sulphate of copper are severe or mild in their action according as they are applied heavily and slowly, or lightly and quickly.]

five to ten grains to the ounce, lapis divinus, glycerole of tannin, Dr. Schoenfeld's ointment of tannate of lead, solution of hydrochlorate of quinine, and so on; each one being changed for another if it does not speedily produce a beneficial action, or if its beneficial action ceases. I have mentioned in the preceding chapter that in extreme cases of pannus a good result may follow inoculation with the discharge of infantile purulent ophthalmia, practiced by simply taking up a little on a probe or scoop, and inserting it within the lower lid. The resulting inflammation is left to run its course without treatment. I have seen several instances in which this method has restored the patient from what was practically blindness to useful vision; but I have seen one in which the corneæ of both eyes sloughed, although they were both highly vascular when the inoculation was practiced; and I have since regarded the plan as one which should be adopted only as a last resource. In the case of which I speak the second eye was inoculated accidentally from the first, and it will occasionally be found that all protective bandages will fail to prevent the occurrence of such an accident. I should therefore regard inoculation as being unjustifiable when only one eye is in a state to require it; and, even when both are equally bad, as a course not to be pursued without full appreciation of its possible dangers.

The occurrence of sloughing of the cornea is not confined to cases of severe conjunctivitis, but is occasionally witnessed from other causes. Of these the most common is injury, when inflicted upon an aged or feeble person. In country districts it often happens that old men, who are unfit for any more laborious occupation, are set to work at trimming quickset hedges; and this "hedging," as it is called, is a fruitful source of sloughing ulcer of the cornea.[1] The patient is slashing about with a bill-hook, and presently receives a smart blow from a twig on the eye, with perhaps a penetrating wound of the cornea from a thorn. His sensations are not very acute, and he goes on with his task for a day or two before seeking advice. At the end of this time the seat of injury is the centre of a ragged ulcer, situated on a gray or pus-colored opacity, which may extend more or less to the margin of the cornea, shading off as it is more distant from the ulcer. Vision may be limited to perception of light. The conjunctiva is injected, but there are no vessels visible on the cornea, and there is little or no pain. If the morbid process be not speedily checked, the centre of the cornea will slough out, and the case may then either terminate in staphyloma, or may go on to complete suppuration of the eyeball. The obvions indications are to sustain the powers of the patient by suitable diet and medicines, and to stimulate the local nutrition by the application of heat; but the most effectual remedy is a prompt iridectomy, which should be performed behind any part of the cornea which may

[1] [Stone-breaking is another employment fruitful of injuries leading to suppuration or sloughing of the cornea.]

remain clear, or, if all be turbid, behind that part from which the centre of the ulcer is most distant. Some years ago, when I was residing at Stroud, I had a crucial instance of the value of iridectomy in such a condition. A poor old man, whose name and face were alike unknown to me, came from one of the neighboring villages with precisely the history given above. I placed him on a couch in my consulting-room, and performed an iridectomy without assistance, and hence without an anæsthetic. He was so much shaken by the operation that I told him to sit down in an adjoining room, in order that he might recover himself before receiving final directions. I was called away for a short time to another case, and when I returned the patient was gone. He had not understood that I had anything more to say to him, and went away as soon as he had rested and felt better. I did not know where he came from, and could not identify him for some weeks afterwards, when I found that his eye had recovered so quickly that he had not thought it worth while to pay me a second visit. The ulcer was firmly healed, without either flattening or protrusion of the cicatrix; and although this covered the natural pupil, yet the gap left by the iridectomy afforded useful vision.

Another form of sloughing ulcer is that which has been described by Professor Saemisch as creeping ulcer of the cornea (*ulcus serpens*), and which resembles the preceding in general character, but commences without manifest cause. It is said to differ from the traumatic form in having a tendency to spread chiefly in one direction; so that the loss of substance is bounded on one side by a perpendicular wall of corneal tissue, while, on the other or spreading side, it slopes off gradually. The creeping and the traumatic ulcers are alike in these respects, that during the stage of sloughing there is no vascularization of the unaffected parts of the cornea, and that the appearance of new vessels passing towards the ulcer from the conjunctiva is among the earliest indications of commencing repair. Professor Saemisch has advocated the treatment of creeping ulcer by an incision through its base, so as to open the anterior chamber and to permit the escape of the aqueous humor. He directs this incision to be reopened daily for some three or four days, and describes excellent results which have been thus obtained. I have used his method in some instances, always with good effect at the time. The spreading of the ulcer was speedily arrested, and healing took place. But in most of the cases the good result was not permanent. The cicatrices yielded after a time to the intraocular pressure, became sources of pain and irritation, and sometimes ultimately required enucleation of the affected eyeball. I regard it as very important to diminish intraocular tension in anticipation of a corneal cicatrix; and thus greatly prefer iridectomy to Saemisch's method; for the additional reason, moreover, that all large corneal incisions, for whatever purpose they may be made, appear to me to be unsound in principle, and unsurgical in practice. The business of the surgeon is to guard the integrity of the cornea with especial care; and any

incision through it, excepting at its margin, unless it be only a small valvular puncture, is liable to alter its curvature, to leave an opaque or yielding cicatrix, and to produce adhesion of the iris. The good effect of Saemisch's incision I believe to be entirely due to the evacuation of the aqueous humor and the consequent diminution of tension, and this may be still better and more completely brought about by iridectomy, without the subsequent daily reopening of the wound. The incision for the iridectomy should in every case be made as far back as possible, so as to lie entirely beyond the true corneal tissue.

The cornea sometimes sloughs as an effect of a ring-shaped ulcer, which ploughs a narrow groove around its circumference, and detaches the centre of the membrane from its sources of blood-supply. The ring-shaped ulcer is usually very near the margin, and is seldom either opaque itself, or surrounded by any border of infiltration, so that it may be overlooked by a careless observer. It occurs chiefly in feeble elderly people, and creeps along but slowly, taking perhaps three or four weeks to complete the circle, and then, so to speak, trephining the cornea and allowing the isolated part to perish. In this form of ulcer I have not found iridectomy necessary, but have successfully practiced repeated paracentesis of the anterior chamber in cases which resisted other treatment, and especially when there was any increase of normal tension. In all the forms of atonic or sloughing corneal ulcer, however arising, it is desirable to support the patient by good diet, and by medicines of the bark and ammonia class, to relieve pain, and to stimulate local nutrition by the application of heat. A certain proportion of the cases will be found, I think, to fall under the category referred to in Chapter III, in which local changes of nutrition are merely expressions of central nerve lesion; and in these the principles of treatment there laid down will be found applicable, and the use of iodide or bromide of potassium, or of both, to be generally indicated. As long as the stage of mere destruction continues, the only admissible local treatment in addition to rest, is the instillation of atropine and the use of hot fomentations; but as soon as repair commences, and vessels are seen proceeding to the margin of the ulcer, it may be desirable to promote healing by stimulating applications. Of these, the insufflation of dry calomel, or the daily insertion of a morsel of Pagenstecher's ointment between the lids, is generally the best; but the calomel must never be used when iodide of potassium is being administered internally. If the system is saturated with the iodide, calomel will be converted into biniodide of mercury on the ocular surface, and violent irritation will be produced. Throughout the case, until healing is complete, the compressive bandage must be kept constantly applied in order to afford regulated support, to exclude dust and changes of temperature, and to avoid irritation from the friction of the lids.

The corneal ulcers which follow the cutaneous eruption of herpes zoster frontalis are, more plainly than any others, the re-

sults of central nerve disturbance, which is now known to be consecutive to inflammation of the investing membrane and connective-tissue elements of the corresponding Gasserian ganglion. I have already mentioned the belief entertained by Dr. Anstie, that the beneficial action of mercury, in procuring the removal of inflammatory products, is more marked within the territory of the fifth nerve than elsewhere; and I have been for some time accustomed to regard it as the most important of all remedies in the class of cases now under consideration. The eye must, of course, be protected by a bandage, and its accommodation must be kept at rest by atropine. Any increase of tension must be promptly met by paracentesis or by iridectomy; and the severe pain which is often present must be alleviated and controlled by the hypodermic injection of morphia. But the really curative treatment, if such there be, is the administration of mercury; and I usually prescribe the perchloride, in combination with the perchloride of iron, and continue it not only until the eye has recovered, but also until the neuralgic pains are subdued, and until the skin has regained its natural sensibility.

The phlyctenulæ, described in the preceding essay as occurring upon the conjunctiva or at the corneal margin, sometimes occur also upon the cornea itself, and occasion small ulcers, each with a leash of vessels running to it from the conjunctiva, and constituting an affection often described as "recurrent vascular ulcer" of the cornea. Phlyctenulæ in this position are more important than when they are seated on the conjunctiva; first, because they often recur with great obstinacy and for long periods of time; next because they are apt to be attended by distressing intolerance of light; and lastly, because they often leave flattened facets or turbid dots upon the surface. The intolerance of light has been supposed to be due to the implication of a nervous filament in the ulcer or in the aggregation of lymph-corpuscles underlying it; and an opacity or a facet would be evidence that the ulcerative process had extended to the true corneal tissue. When phlyctenulæ appear on the cornea, the use of astringents is inadmissible in the early stages, for which atropine, soothing applications, and a compressive bandage should be employed; and only when all the ulcers have commenced to heal may some mild stimulant, such as Pagenstecher's ointment, be applied [or dry calomel be dusted into the eye]. If there is severe photophobia, either in this or in any other affection of the cornea, the symptom is one which may call for division of the orbicularis muscle at the outer canthus, on the principles and in the manner already fully described at pp. 195–197. A photophobia of a milder character may sometimes be effectually relieved by the use of a cold douche or spray to the closed lids; but I have no experience of the plan often described in books, of suddenly plunging the face into a basin of cold water.

For the cure of recurrent corneal ulcer, or rather for the cure of the tendency to recurrence, Mr. Critchett introduced the prac-

tice of inserting small setons in the temples; and his example has been followed by many other surgeons who have not been equally careful that the setons should be placed only in the hairy scalp, where they and the marks they leave are alike concealed from view. I often see children, even girls, whose temples below the hair are disfigured by unsightly scars; and whose attendance at another hospital from that in which the injury was inflicted upon them goes far to prove that it had been of little or no avail. I should be quite prepared to insert setons in any cases which resisted milder means; but such cases, if I may judge from my own experience, will not be very frequently encountered. In a few instances of extreme obstinacy, which have resisted all other treatment, setons included, I have seen cure follow the performance of a small iridectomy—one which just broke the continuity of the sphincter of the pupil. After the operation there has been no more recurrence of ulceration, and sight has undergone gradual improvement from the clearing up of corneal opacities. In this respect, however the opacities may have been produced, the action of iridectomy is often very remarkable, probably because, by diminishing the tension of the eyeball, it permits increased freedom of circulation, a less restricted entrance of arterial, and a less restricted outflow of venous blood. With regard to its influence in breaking the chain of recurrent ulceration I have no hypothesis, and can only state a fact of which I have been rendered sure by sufficient opportunities of observation.

The true inflammations of the cornea range themselves naturally into three classes, accordingly as they tend to the development of vessels in the membrane, to interstitial cell-proliferation or plastic deposit, or to the formation of abscess or ulcer. But all forms of inflammation of the cornea, or, as it is conveniently called, keratitis, are broadly distinguishable from inflammation of the conjunctiva by this marked character, that they will not bear astringent or irritating applications. These things, which are among the essentials of treatment in dealing with the inflamed conjunctiva, are prejudicial to the inflamed cornea under almost all circumstances; the only exception being that they may be used with advantage when the acute symptoms have passed away, in order to stimulate the healing of an ulcer, or to promote the absorption of a deposit. The error of prescribing a lotion of sulphate of zinc, or of nitrate of silver, during the early stage of a manifest keratitis, is one that will, it may be hoped, never again be committed; but there are certain cases, apparently of conjunctivitis, usually marked, perhaps, by more nervous irritation than would attend conjunctivitis alone, and with a tendency, only to be perceived by careful examination, to the passing on of vessels from the conjunctiva to the cornea. In these cases such an error might not be inexcusable; but it would be none the less likely to be followed by injurious consequences, and would often convert a comparatively trivial and manageable disorder into one of great severity and obstinacy. Keratitis, whatever else it may require, invariably requires local

sedatives and local rest; and when it is even threatened, the instillation of atropine, the enforcement of functional disuse, and the application of a protective bandage, should be regarded as measures of course, independently of any constitutional or other treatment which may be called for. In the somewhat hybrid cases just referred to, in which there is unmistakable conjunctivitis, with a tendency to extension of vessels upon the cornea, it is often necessary to combine the different methods of treatment which are required for the two conditions. When this is done, too much care cannot be taken to keep the astringent away from the cornea, and to limit its action to the retrotarsal folds. These may be touched with a stick of diluted nitrate of silver, or of lapis divinus, as often as circumstances may require; but the application must be carefully neutralized or removed before the lids are suffered to return to their natural position; and atropine and protection must be used at the same time, together with any internal medication which circumstances may demand.

The so-called vascular keratitis, the form of inflammation of the cornea which tends to the development of vessels in the membrane, is totally unlike, both in its character and in its consequences, the vascularization of the cornea that is caused by granular lids, and that is known as pannus.[1] The latter is a mere hypertrophy of epithelium, with attendant superficial vascularity; and the individual vessels are large and plainly visible, are separated by wide and manifest interspaces, are developed in a direction from above downwards, and are not bounded by any approach to a regular outline. In true vascular keratitis, in the early stage, we see manifest hyperæmia of the conjunctiva, and, continuous with this, a series of fine vascular loops passing upon the cornea, and covering a crescentic area. The first formed crescent is generally, perhaps invariably, at the upper part of the cornea; and before long a second appears at the lower part—the two crescents facing each other, and each having its concavity directed towards the pupillary region. Presently we see that each vascular crescent is somewhat elevated above the healthy surface, and is bordered along its concave margin by a line of swollen and turbid epithelium, which is pushed, so to speak, before its advance. Resolution and retrogression may take place at any period; but if the case is a severe one, and proceeds unchecked, the vascular crescents steadily enlarge until first their belts of precursory turbidity, and then the vascular surfaces themselves, meet at or below the horizontal meridian, and the cornea becomes covered with vessels which may be so small, and so closely packed, as to be individually undistinguishable by the naked eye, and to form a generally red surface. A writer of the generation now passing away has been much criticized by some of his juniors for comparing an inflamed cornea to "a ripe cherry, or a piece of red cloth." The comparison is not felicitous if applied

[1] [A true vascular keratitis, or as it is often called, an acute pannus, is not unfrequently observed in the course of a granular conjunctivitis.]

fairly be suspected that the proper key has not been struck, and that fresh consideration should be given to the case. In many instances I have seen great benefit derived from counter-irritation on the temples, and for this purpose I usually paint the skin with tincture of iodine, in each ounce of which four grains of morphia have been dissolved. The painting should be repeated twice daily until considerable soreness is produced, and afterwards with sufficient frequency to maintain a decided action.

In the way of local treatment, besides the employment of atropine, and the enforcement of the shelter and functional and physical rest which all corneal maladies require, a severe case of vascular keratitis will often call for iridectomy. In my earlier experience, I approached the use of this remedy tentatively, by performing the operation only on the worse eye of the two, when both were affected in the same patient. I found, in such cases, that the eye operated upon invariably made a better recovery than the other. I have no hypothesis with regard to the *methodus medendi* of the operation; which may possibly be useful as a means of taking blood directly from the vessels of the eyeball, possibly on account of the greater freedom of circulation incidental to diminished tension, possibly by the direct division of some of the nerve filaments and bloodvessels proceeding to the inflamed part. In selecting the place of operation, I have generally been guided by optical considerations, and have excised the lower and inner quadrant of the iris, so as to form the artificial pupil in the position which would most speedily be useful for the purposes of vision. Apart from the influence of the iridectomy in controlling, to some extent, the course of the disease, it is highly useful in the manner last indicated, by affording an artificial opening through which light may find entrance, while the centre of the cornea is still obscured by residual opacity. In order to promote the removal of this residual opacity, I have used with great advantage the plan of Professor Rothmund, already mentioned, of injecting a solution of common salt into the subconjunctival tissue.

The forms of keratitis which tend to interstitial cell-proliferation or plastic deposit, but neither to vascular development nor to the formation of pus, have their chief type and example in the variety which attends upon inherited syphilis,[1] and for our knowledge of which we are indebted to the genius and the industry of Mr. Hutchinson. Thanks to his labors, we now recognize a certain physical type as that which is presented by the offspring of syphilitic parents. In the most pronounced examples, such persons have a flattened or somewhat concave *facies;* a general effect which is chiefly due to imperfect development of the nasal bones and the maxillæ, coupled with projection of the chin and of the frontal eminences. The angles of the mouth, and the cheeks near the alæ of the nose, are often furrowed by the cicatrices of former

[1] [In severe cases of this type of keratitis we have seen both marked vascular redness of the cornea, and the formation of pus in its substance; we have also met with pus in the anterior chamber, which appeared, however, to have been derived in part at least from the iris.]

ulcers. The skin is of coarse texture, the complexion pallid or earthy, the whole aspect prematurely senile. The temporary teeth may present no peculiarities, but the permanent teeth exhibit characteristic signs of the inherited diathesis. The central incisors of the upper jaw are altered in shape, being bounded laterally by curved lines, with their convexities outwards, and presenting a concave or crescentic notch at their lower margins. The lateral incisors of the upper jaw are often similarly malformed, and the incisors of the lower jaw are often small, distorted, and "peggy" [sometimes notched]; but the peculiar outline of the upper central incisors may be regarded as pathognomonic of inherited syphilis. The disease of the parent or parents is found to wear itself out as life continues, so that a woman may have one or two abortions followed by one or two still-births at full time, then by living children, who show the evidences of inherited syphilis to a constantly diminishing extent, and lastly by children in whom these evidences are no longer discernible. The original severity of the parental malady may also have its influence upon the amount of transmitted taint; and it follows that we meet with inherited syphilis in various degrees of severity. Some of the inheritors may be recognized across a street by the above-mentioned deformities; while others present no sign but the characteristic shape and notching of the upper central incisors [and others not even that]. I have myself a strong conviction that the physical peculiarities and proclivities which are usually due to syphilitic parentage are sometimes produced, even in an aggravated form, by vaccination with lymph yielded by a vaccinifer who has himself inherited the disease, and that this may happen without the production of any derangement of the course of the vaccine vesicle, or of anything which could at the time be recognized as evidence of a specific inoculation. In other words, if we vaccinate a child who is the subject of inherited syphilis, and obtain apparently normal vesicles, and if from one of these apparently normal vesicles we vaccinate a healthy infant, and again obtain normal vesicles, I think that the taint of the syphilitic vaccinifer may nevertheless be conveyed to the vaccinated in such a way as eventually to produce, in the latter, the constitutional conditions and bodily defects which time will develop in the former. I am well aware that this belief is not generally entertained; and I do not propose in this place to enter into any discussion of the grounds on which it rests. I am content to place it on record in an explicit manner, and, in the phrase of Sydenham, to leave it to "time, the discoverer of the truth." The last Vaccination Act provides for the registration of vaccinifers, so that we may hereafter be able to ascertain the source of the lymph used in every case, and, where the vaccinifer is still living, to follow him and to examine into his state. If we find, ten years hence, as I think we shall find, that there are many cases in which patient A, who presents clear evidence of what we now regard as inherited syphilis, but whose parents and brothers and sisters are not syphilitic, has been

vaccinated from patient B, whose parents and brothers and sisters are syphilitic, and who is syphilitic himself, then I shall consider my position to be established, and shall hold it as proven that A derived his syphilis from B. In the meanwhile it is useless to discuss the question, because the only data on which it could be decided do not exist. In more than one instance in which I have had strong presumption that an apparently inherited syphilis was really vaccinal, I have found it impossible, after the lapse of ten or fifteen years, to discover anything about the child from whom the lymph had been obtained. I would fain urge my suspicions, however, as a reason why a vaccinator should repudiate, as a source of supply, not only those children who are themselves obviously syphilitic, but also those whose parents have at any time suffered from the disease. I have heard great stress laid upon the importance of vaccinating with "pure" lymph, without admixture of blood; but I fail to see any physiological or other ground for the belief by which this advice is dictated. The fluid of lymph is, I suppose, derived directly from the blood; and is, if we may receive Chauveau's experiments, simply liquor sanguinis, holding certain specific particles of vaccinal contagium in suspension. I am not aware of any evidence which connects syphilitic infection with the blood-corpuscles rather than with the fluid in which they float; and I should be unwilling to admit the "purity" of any secretion or exudation which had syphilitic blood as its direct and only source.

Returning from this digresion, we find that the subjects of what we will call simply "inherited syphilis" are liable to—nay, are almost sure to suffer from, a peculiar form of interstitial keratitis. The patients in whom the syphilitic state is extremely manifest are usually attacked by keratitis in childhood, often at from eight to ten years of age [not infrequently before the commencement of the second dentition]. Those in whom the taint is less marked do not develop the corneal malady quite so early in life; and those in whom the taint is very feeble may escape altogether, or may escape until adult age, or until they are exposed to some combination of unfavorable or debilitating circumstances. I have seen one very well-marked case which commenced at the age of thirty-five in a woman weakened by childbearing and want of nourishment; but, as a rule, the disease shows itself, if at all, prior to the completion of growth; and it occurs only once in a lifetime. Its characters have been so described by Mr. Hutchinson, that they cannot be better stated than in his own words:

"Chronic interstitial keratitis usually commences as a diffuse haziness near the centre of the cornea of one eye. There is at this stage no ulceration, and exceedingly slight evidence of the congestion of any tunic. The patient, however, almost always complains of some irritability of the eye, as well as of dim sight. If looked at carefully, the dots of haze are seen to be in the structure of the cornea itself, and not on either surface; they are also separate from each other, like so many microscopic masses of fog. In the course

of a few weeks, or it may be more rapidly, the whole cornea, excepting a band near its margin, has become densely opaque by the spreading and confluence of these interstitial opacities. Still, however, the greater density of certain parts—centres, as it were, of the disease—is clearly perceptible. Early in this stage the comparison to ground-glass is appropriate. There is now almost always a zone of sclerotic congestion, and more or less intolerance of light with pain around the orbit. After from one to two months the other cornea is attacked and goes through the same stages, but rather faster than the first. A period in which the patient is so far blind that there is but bare perception of light now often follows, after which the eye first affected begins to clear. In the course of a year or eighteen months a very surprising degree of improvement has probably taken place. In milder cases, and under suitable treatment, the duration may be very much less than this, and the restoration to transparency complete, but in many instances patches of haze remain for years, if not for life. In the worst stage, the corneal surface looks slightly granular, and from the very beginning it has lost its polish, and does not reflect images with definite outlines. In certain cases, after the ground-glass stage is passed, a yet more severe one ensues, in which the whole structure of the cornea becomes pink or salmon-colored from vascularity, and in these, crescentic fringes of vessels are often noticed at its circumference. In the best recoveries the eye usually remains somewhat damaged as to vision, and often a degree of abnormal expansion of the cornea is apparent. Only in one or two cases have I ever observed ulcers of distinguishable size on the surface of the cornea, and I have scarcely ever seen pustules on any part of it." [*Syph. Dis. of the Eye and Ear*, pp. 28–29.]

It is remarkable that the syphilitic character of this affection may be said to have been half discovered by Sir William Wilde, who described it, a quarter of a century ago, as a variety of what was then called "strumous ophthalmia," and who laid much stress upon the value of perchloride of mercury in its treatment. Sir William does not appear to have suspected the pathology which was underlying his therapeutics; and he thus furnishes a curious example of how it is possible to stand on the verge of a great truth, and yet to remain unconscious of it. Mr. Hutchinson, on the other hand, was led from causation to cure by easy steps; and in the work in which he established the nature of the malady he established also the principles on which it should be treated. Speaking generally, it may be said that the perchlorides of mercury and iron, with cod-liver oil, will accomplish all that medicine can effect to conduct a case of interstitial keratitis to a successful issue. When the early symptoms are severe, or when the syphilitic taint is strongly marked, it may be well to employ also mercurial inunction; and the golden rule of using only soothing local applications must never be lost sight of. Since these principles have been understood and acted upon, cases of great severity have been comparatively seldom seen; and extension of the disease to

the ciliary body, the choroid, or the iris, is now of rare occurrence. The severe cases referred to by Mr. Hutchinson, "in which the whole structure of the cornea becomes pink or salmon-colored from vascularity, and in which crescentic fringes of vessels are often noticed at its circumference," in which, in fact, the phenomena of the vascular form of keratitis become engrafted upon those of the interstitial, are seldom witnessed except as the results of neglect or maltreatment;[1] and in this disease, as in so many others, a precise knowledge of its character, although it somewhat dispels expectations of cure, yet enables the surgeon to establish conditions which promote and expedite recovery, and enables him at the same time to allay the anxieties of friends by forewarning them of the slow progress of events, and of the almost certainty that the second eye will be affected, while at the same time he confidently predicts a favorable issue.

Except in the rare instance in which it produces irritation, the instillation of atropine should be employed in all these cases; but the rest of the local treatment must be almost entirely governed by the severity of the symptoms. In cases in which there is little or no tenderness of the ciliary region, and little or no photophobia, the eyes may be left uncovered, and if the weather be fine and mild the patient may take daily exercise in the open air; wearing a shade or large blue spectaces, or no protection, according to the intensity of the daylight and the demands of comfort. If blue spectacles are used, they should always afford lateral as well as direct shelter; or the eyes will be distressed by the white light whenever they are turned to either side. But if there is ciliary tenderness, or any degree of intolerance of light which is irksome, or which, even if slight, shows signs of increase, then the patient should be kept during the day in a dimly lighted room, and may spend a good deal of time in bathing the closed lids with cool or cold water, according to the temperature of the atmosphere and to the effect of either upon the local sensations. Under such circumstances, in favorable weather, outdoor exercise may be taken in the evening; and the symptoms of irritation will in most cases soon subside. If they continue, it will be undesirable to deprive the body generally of the stimulus of light; but a protective bandage may be so arranged as to exclude it from the eyes entirely. For this purpose, the piece of fine linen laid upon the closed lids should be covered by black silk, over which the pad of carded cotton-wool should be arranged in the usual manner, and covered with another piece of black silk before the retaining band is applied.[2] Such a bandage will allow the patient to go out in the daytime or to live in lighted rooms; but it has the disadvantage of being heating; and it should be removed in a dark room three or four times a day, for half

[1] [We have occasionally observed this appearance in a comparatively early stage of cases in which no treatment had been employed.]

[2] [A flap of linen hanging from the forehead and covered by a second larger flap of black silk, or possibly by two thicknesses of the silk, will sufficiently exclude light and be less heating to the eyes than the arrangement described in the text.]

an hour at a time, in order that cold bathing may be practiced. If ciliary tenderness increases, and the patient will bear any loss of blood, a leech or two may often be applied over the temporal muscle, close to the margin of the orbit, with great advantage; and if photophobia be at all extreme, so that the tender ciliary region is compressed by the eyelids, the orbicularis muscle should be divided at the outer canthus in the way already described. As the acute stage gradually passes away, the patient may return by degrees to the habits and freedoms of health; but the administration of mercury should usually be long-continued (perhaps with occasional intervals of a week or two); and, when nothing remains but cloudiness of the cornea, the application of Pagenstecher's ointment has often seemed to me to be beneficial, and to promote the return of transparency. Atropine is not required after the acute symptoms have subsided; unless on the ground that dilatation of the pupil is useful as regards vision.

Before leaving the subject of the applications suitable to the early periods of the malady, I must mention, in order to condemn, one bearing a name which might seem to imply the possession of soothing properties. I have lately seen a young lady in whom an attack of interstitial keratitis had been rendered unnecessarily severe, not only by the omission of the atropine and the mercury which it required, but also by the daily instillation of *vinum opii*. Now *vinum opii*, when applied to the eye, is simply an active irritant. The quantity of opium which it contains is too small to act as a sedative, or to act in any way; and the liquid should only be regarded as so much diluted alcohol. Now, alcohol, while it occasions fully as much smarting as any of the metallic astringents, does not exert their beneficial action upon an inflamed epithelial surface; and I am not aware of any useful purpose which can at any time be fulfilled by its application to the eye. I have never myself prescribed either *vinum opii*, or any other tincture, for this purpose; and I have seen nothing but mischief follow, even if it were but the retardation of spontaneous recovery, when such preparations have been prescribed by others.

The varieties of keratitis which are included in the third chief division vary in their external aspect, accordingly as the disease may be primarily ulcer or abscess—the process of disintegration commencing on the surface of the cornea in the first case, and in some of the interior laminæ in the second. In abscess, moreover, spontaneous perforation may take place internally, into the anterior chamber; so that the resulting ulcer will be exposed neither to friction of the lids nor to atmospheric influences. The inflammatory ulcer is distinguished from the sloughing forms by being usually attended by much irritability of the eye, and by some vascularity of the cornea, during the desructive stage; and also by the transparency of its base and margin, characters which may occasion the very existence of the ulcer to be overlooked. Abscess commences as an interstitial speck, at first grayish in color, but changing to a pus-yellow as it enlarges, and often acutely tender

to the touch; a point which may be best determined by the gentle application of the extremity of a blunt probe. The pus may tend to speedy perforation, either externally or internally, or in both directions at once; or it may separate the laminæ of the cornea and burrow or spread between them. Whether it perforates internally, and enters the anterior chamber, or separates the laminæ, its course in either case is governed by gravitation; and thus two conditions are produced which the ophthalmic surgeons of an earlier period were very careful to distinguish from each other, and which it is at any rate better not to confound. Pus which has entered the anterior chamber constitutes what is called hypopyon. If very small in amount, it may appear as a mere crescentic line within the lower margin of the cornea; but its tendency is to fill the anterior chamber to a certain level, and to present a plain surface which remains horizontal in every position of the head. Pus which has gravitated between the laminæ to the lower part of the cornea constitutes what is called onyx, from a fancied resemblance to the lunula at the base of a finger-nail. It differs manifestly from hypopyon in presenting a superior boundary which is not necessarily either straight or horizontal; while, apart from these peculiarities, the two conditions, especially if seen in profile, can hardly fail to declare their nature to any careful observer.

As occurring in private practice, inflammatory ulcers of the cornea are usually seen in a very early stage, and abscesses at a time when pus formation is rather impending than actual. Under such conditions atropine, rest, and shelter, must of course be prescribed; and the surgeon has also to consider the prospects of advantage which are respectively offered by hot or cold local applications, as well as the plan of general treatment which will be most likely to modify favorably any general derangement of nutrition in which the ocular disorder may have its origin. It is in dealing with such questions that the skill and clinical experience of the accomplished medical practitioner declare themselves, while the mere specialist is apt to break down utterly. So many considerations of age, constitutional power, diathesis, and personal peculiarity require to be taken into account, that it would be impossible to do any justice to them within the limits of this treatise; and I will only say that, subject to these considerations, quinine is a medicine which it is generally desirable to administer, and to administer in such a way that its effects upon the system may be somewhat rapidly produced. It may often be advantageously combined with iron, and nearly always with some anodyne or hypnotic. In a moderately robust patient, with exalted sensibility of the eye, local cold will usually be beneficial; and heat in feeble persons, or when sensation is somewhat torpid. In these two directions, however, it is best for the surgeon to feel his way—ordering his applications to be at first nearly of the temperature of the surface, and cooling or warming them according to the effects they produce and the feelings of the patient. By such management, and by careful regulation of diet and general regimen, the impending abscess may often be averted,

or the incipient ulcer may enter upon its stage of repair when as yet but little more than epithelium has been lost. If the ulcer should continue to deepen or extend, the character of the general treatment must be reconsidered by the light of its failure to arrest the progress of the malady; and, under such circumstances, a collyrium of hydrochlorate of quinine, containing five grains of the salt to an ounce of water, may sometimes be used with great benefit, being dropped into the eye in the ordinary way, and repeated more or less frequently according to circumstances. If the abscess should enlarge, there is yet another resource, and one of which I am accustomed to avail myself as soon as the presence of pus, however small in amount, is no longer doubtful. In the cornea, as elsewhere, the early evacuation of an acute abscess is the only sound method of practice, and has the advantage of providing for the exit of the pus in the most desirable direction and with the least possible injury to surrounding parts. Evacuation through the surface would lead to an open wound, which for many reasons it is highly desirable to avoid; and the plan I pursue is to introduce a fine cutting needle through the sclero-corneal junction, and to open the abscess from within, through Descemet's membrane, without perforation of the remaining anterior laminæ of the cornea. When this has been done, the wound of entrance of the needle may be opened from time to time with a lacrymal probe or with the beak of a Weber's canaliculus knife, so that the aqueous humor may escape, carrying with it any recently secreted pus or shreds of disintegrated tissue. Under the influence of this treatment, speedy amendment may generally be looked for.[1]

When the anterior laminæ of the cornea are removed to some depth by ulceration, the floor of the ulcer, no longer able to resist the pressure exerted upon it through the medium of the contained fluids by the muscles of the eyeball, soon assumes a convex outline; and, when little but the highly elastic membrane of Descemet is left, may even appear as a projection, raised above the level of the surrounding parts. Ultimately, in such cases, the apex of the projection will give way; and when it has done so repair will generally commence. It sometimes happens, however, in such cases, that the sides of the opening of the cornea may become lined, so to speak, by the projecting Descemet's membrane, any two portions of which, although they may lie in contact, have no disposition to cohere, or to throw out plastic material. In this way troublesome sinuses may be left by corneal ulcers, and may resist all treatment until their walls are denuded of the adventitious lining membrane by the very delicate and difficult process of stripping it away by fine forceps. Hence, when rupture of the floor of a corneal ulcer seems to be threatened, it is desirable to try and avert the impending evil by diminishing ocular tension, either by

[1] [In abscess of the cornea when the collection of pus is in the neighborhood of the scleral border, an incision may be made with a narrow lance-knife through the whole thickness of the cornea.]

repeated paracentesis or by iridectomy. If the ulcer is not central, paracentesis may be tried in the first instance; but if it is central, so that the cicatrix must necessarily obscure vision, it is best to have recourse to iridectomy without delay, and thus not only to reduce the tension, but also to make by the same procedure, and in the direction most likely to be ultimately available, the artificial pupil which must in time be required. If, notwithstanding these measures, perforation should be imminent, the surgeon should anticipate it by thrusting a probe through the apex of the projection; of course carrying it obliquely into the anterior chamber, and with such control both of the patient's eye and of his own hand that he may incur no risk of wounding the anterior capsule or of dislocating the lens. By this manœuvre the torn shreds of Descemet's membrane will be pushed inside the chamber, where they will place no obstacle in the way of the complete healing of the wound.

In hospital practice, it is not uncommon to see cases for the first time in a much more advanced condition; an ulcer already large and on the point of perforation, or even having perforated; or an abscess which has extensively separated the corneal laminæ, or has discharged itself either externally or internally. The principles of treatment already stated will apply equally to these conditions; among which only a large hypopyon and an ulcer which has already perforated require any special consideration. The pus of hypopyon is often of a fibrinous or coherent character, and no time should be lost in making a free marginal incision for its escape. Whether or not a piece of the iris is to be excised, the knife should be used as if for a large iridectomy. Any semi-solid pus which does not pass out of its own accord may be gently removed by iris forceps, and the lips of the wound may be reopened with a probe on the following day, if any fresh collection should have taken place. In most cases, hypopyon will be accompanied by some degree of iritis —easily discoverable by the resistance of the pupil to atropine— and then the operation of iridectomy should generally be completely performed. When a corneal ulcer has perforated, the principal point to receive attention should be the risk of staphylomatous protrusion of the cicatrix. In order to prevent this, the powers of the patient should be sustained by strengthening medicines and the best diet which circumstances will permit; and the eye itself should be supported by a compressive bandage, very carefully and firmly applied, and worn for some time after healing is complete, and until the scar tissue has become firmly consolidated. If, notwithstanding the pressure, a tendency to protrusion should appear, an iridectomy should be made where there is the broadest portion of undamaged cornea, and the bandage should be continued as before.

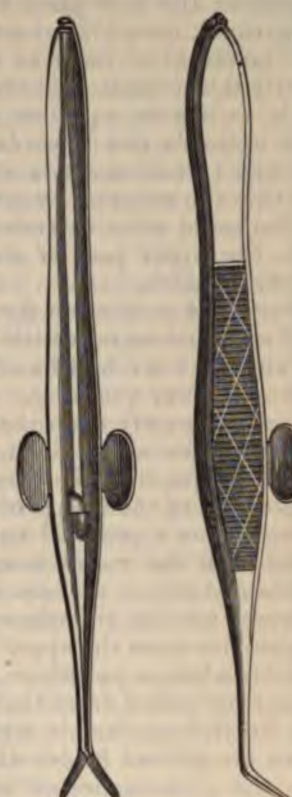
In many of the foregoing conditions there will be found a state, not exactly of inflammation of the conjunctiva, but of conjunctival hyperæmia and swelling, or almost hypertrophy, affecting chiefly

the caruncle, plica semilunaris, and lower retrotarsal fold. Under such circumstances these parts may be touched with an astringent, as with lapis divinus, or solid diluted nitrate of silver; care being always taken that the effect of the application is limited to the congested portions of membrane, and not permitted to extend itself to the cornea. The observance of this precaution practically excludes the employment of liquid applications.

After the healing of a corneal ulcer, the residual opacity should generally be left untouched for some months, until it has become firmly consolidated, until the eye has ceased to be irritable, and until the general health is in a thoroughly satisfactory condition. An exception to this rule is afforded by cases in which irritability is maintained by an adhesion of the iris to the cicatrix; and whenever such an adhesion exists, whether it is productive of irritation or not, its detachment should be the first consideration in the surgical treatment of the case. Very frequently, the position of the cicatrix will be such as to interfere with vision by covering the pupil, and hence to require the formation of an artificial pupil in order to restore the eye to usefulness; and in some cases the position of the adhesion may be such that its detachment, and the formation of an artificial pupil in the best position, may without difficulty be accomplished simultaneously. When this is not the case, it is distinctly better to do one thing at a time, and to detach the adhesion first. This may often be accomplished by introducing an iridectomy knife at the part of the corneo-scleral junction which is nearest to the adhesion, and by directing the point in such a manner that it may perforate the centre of the band, which will then be severed on either side of the perforation as the angular blade is pushed onwards. When the lens would be endangered by this proceeding, as when the aqueous humor escapes by the side of the blade before complete division of the band is effected, the knife may be at once withdrawn, and the operation completed by a cutting-hook or by scissors. The hook which I find most useful is a trifling modification of one that was contrived by Mr. Streatfeild for the purpose of separating adhesions of the iris to the anterior capsule. It is, in effect a tiny spatula, smooth and rounded at its extremity, bent on the flat like an iridectomy knife, and with a cutting notch on one side of its blade. It is introduced through the wound and carried forwards until the band is caught in the notch, so that it may be divided as the blade is withdrawn. In withdrawing any kind of hook from the anterior chamber it is necessary to be careful that it does not catch in the posterior lip of the opening; and for this purpose the point of the hook should be turned a little forwards, and its back should be kept in contact with the angle of the wound. If scissors are used, the best form will usually be the iridotomy scissors of M. de Wecker, shown in Fig. 66, which have blades with smooth and rounded extremities, and are therefore, if used with due care, little liable to injure the capsule of the lens. They should be in-

troduced closed, through a small opening, suffered to expand when they reach the adhesion, pushed on to include, and then closed to divide it. In all these operations the instrument, whether knife, hook, or scissors, should never cross the pupil to reach the adhesion, but should always be entered at the nearest point of the periphery of the cornea; as in no other way can the safety of the lens be assured. For the same reason, and also to avoid detachment of the iris at its ciliary margin, the traction of the hook must always be from the adhesion towards this margin. In most cases, however, an artificial pupil for the improvement of vision must be made in the opposite direction, where the distance from the periphery of the cornea to the adhesion is the greatest, and where, consequently, the broadest band of clear cornea is available. For this reason it is often impossible to make the artificial pupil through the same wound by means of which detachment of the adhesion is effected; and hence the two operations can seldom be performed at the same time. When once the iris is set free, and a sufficient interval for the recovery of the eye has been permitted to elapse, the artificial pupil may be made in the position which will be likely to afford the best results. Before deciding upon this position, it is proper to ascertain how far the curvatures of the cornea may have been altered by the formation and contraction of the cicatrix. For this purpose the best method is fully to dilate the pupil with atropine, and then carefully to study the erect image with the ophthalmoscope. The artificial pupil may be placed behind any part of the cornea through which the smaller retinal vessels appear clearly defined; for in such a place, even if the cornea is flattened, it is not distorted, and the eye will at the worst be hypermetropic, requiring the habitual use of a convex lens. But a pupil must not be made behind a part of the cornea through which the smaller vessels appear either wavy or blurred, because here we shall no longer be dealing with a surface of revolution but with one which is distorted as well as altered, and distorted in such a manner that no lens will correct its faults. If the indistinctness of the vessels is limited to such as proceed in certain directions, while others are clearly visible, the fault may

FIG. 66.



be remediable by a cylindrical lens, to be determined and used in the way which I shall have occasion to describe in treating of Astigmatism; and, if no distinct view of vessels can be obtained through any part of the cornea, then it may be desirable to make a pupil in the best place that can be discovered. Other things being equal, an artificial pupil is most useful in the lower and inner quadrant of the eye; next, if made directly inwards; next, directly downwards; and then, in succession, downwards and outwards, outwards, upwards and outwards, directly upwards, and lastly upwards and inwards. When made in either of the two last-named positions it is often desirable, at a subsequent period, to divide the superior, external, and internal recti muscles, so that the increased relative strength of the inferior rectus, may bring down the upper part of the cornea towards the middle of the palpebral fissure.

[The place of election for an artificial pupil is, doubtless, to the nasal side, and on or a little below the horizontal meridian of the eye, and the next best location would seem to be in the outer, or outer and lower quadrant. It is important that the pupils of the two eyes be nearly upon the same level, and therefore the choice of position for an artificial pupil must often turn upon the position of the pupil of the other eye. Regard must be paid, too, to the position of the fissure of the eyelids relatively to the cornea.

The author's proposal to divide the superior rectus muscle, together with the rectus internus and externus, can, of course, be entertained only in the case of a person who has lost the other eye; otherwise vertical diplopia would be produced. Even in such cases an operation upon the upper lid, as for ptosis, would be a safer, and probably a better procedure, but even this will seldom be indicated, if we may judge from the experience of cataract extraction by Von Graefe's method, in which we not unfrequently see the pupil drawn far upward behind the upper margin of the cornea.]

In the performance of the operation it must be remembered that the object in view is to make a small aperture for the admission of light. A large artificial pupil never affords such good vision as a small one; and an artificial pupil which exposes much of the periphery of the lens is always objectionable. It is therefore proper to make a small external wound, which should be wholly in the sclero-corneal junction, and scarcely ever, on account of the opacity which might attend it, in the clear cornea. The narrowest iridectomy knife, or a broad cutting-needle, will be sufficient for this purpose. If the iris should at once bulge through the wound, it may be seized with forceps, drawn out very gently, and cut off with scissors close to the point where it is held. The remaining portion will generally return at once within the chamber; but if it should not return it may be gently replaced by a probe, or by the end of a strabismus hook, and the reduction may be completed by removing the speculum, and making light rotatory friction over the wound through the medium of the closed eyelid. If the iris does not bulge, it must be drawn out by

Tyrrell's blunt hook, or by such fine canula or other forceps as will pass through the small incision. The forceps should be introduced closed until their teeth approach the margin of the pupil. They must then be suffered to expand a very little, must be closed upon the small fold of iris which will present itself between them, and must be gently withdrawn, the iris being cut and treated as before. Tyrrell's hook (Fig. 67) should be introduced with the shaft and the bent portion both in the plane of the incision, until the extremity of the bent portion has passed beyond the margin of the pupil. The extremity should then be turned backwards, and the hook withdrawn a little, so as to catch the margin. When this is well engaged, the extremity should be turned forwards towards the cornea, so that the hook, bringing the iris with it, may be drawn out easily through the wound. The scissors should be held prepared, and should divide the iris as soon as the hook is clear of the eye. Whatever mode of operating is adopted, a sudden roll of the eye whilst the iris is being drawn out may greatly embarrass an inexperienced operator, and may cause him to detach a much larger portion than he intended. The practiced ophthalmic surgeon acquires the art of making his hands accommodate themselves, almost instinctively, to such movements; but the beginner will do well to guard against them by being very careful that the degree of anæsthesia is sufficiently profound, and by having the globe fixed by an assistant during this critical period of the operation.

FIG. 67.

Two other methods of making an artificial pupil have been devised, one by Mr. Critchett, the other by Mr. Bowman; and the result obtained by Mr. Bowman's operation is brought about in a different manner by M. de Wecker. Mr. Critchett's operation was called by him *iridodesis*;[1] and its object is to determine precisely the size and position of the new opening, and also, in some cases, to leave the natural contractile margin of the pupil intact. For this purpose he makes a small incision into the anterior chamber in the usual manner, and places a tiny loop of silk upon the globe, in such a way that it may encircle the incision. He next introduces his hook or forceps through the loop and the incision, seizes the iris, and draws out the portion seized. An assistant then picks up the two ends of the silk with two pairs of cilia forceps, and tightens the loop so as to strangulate the portion of iris which has been drawn out. This portion drops off in a day or two, and leaves that with which it was originally continuous incarcerated in the cicatrix of the incision.

For the successful performance of this operation it is necessary that the ends of the silk should be seized and tightened evenly

[1] [Mr. Critchett named his operation *iriddesis*. See *Oph. Hosp. Rep.*, I, p. 220.]

and promptly, by a movement which shall neither displace the circle of the loop from contact with the globe, nor drag it away laterally from the incision. These three requirements are difficult of accomplishment, more difficult, certainly, than to make the incision, place the loop, and draw out the iris: from whence it follows that iridodesis is only practicable when the surgeon can command the help of an assistant who is at least equally skilful with himself. An ingenious German, whose name escapes my recollection, partly overcame this limitation of the applicability of the procedure. He constructed an instrument not unlike a miniature polypus snare, by means of which the principal operator was enabled to control and tighten the loop himself; and in this way a more extended experience of the operation was obtained. Before long, cases were recorded in which the incarceration of the iris, thus designedly accomplished by mechanical means, was followed by results like those which are apt to attend upon the incarceration produced by accident or disease; that is to say, by intractable inflammation, commencing in the iris, extending to the ciliary body and the choroid, and terminating in wasting of the eyeball and loss of sight, with possible sympathetic involvement of the other eye also. The majority of surgeons consider these risks too great to be incurred; but I believe that Mr. Critchett himself still performs the operation in suitable cases, and that disastrous results have not fallen under his own observation.[1] It is trite to observe that no amount of negative testimony can outweigh that which is positive; and the circumstances of London ophthalmic practice are such that a patient who becomes the victim of troubles which he did not expect will often carry his griefs to the hospital or the consulting room of some fresh adviser. Hence it happens that we all have opportunities of seeing the occasional failures of those who are habitually rewarded by deserved success; and we all learn modesty from the knowledge that our own failures are certain, in their turn, to afford materials for the enlightened and candid criticism of others.

Mr. Bowman's method is to incise the iris radially, from the pupillary margin towards the periphery, thus making a mere slit, the edges of which will afterwards separate so as to afford the required opening. He first made a puncture through the cornea at a point opposite to the intended incision, and through this puncture introduced into the anterior chamber a very narrow flat knife, with a blunt extremity and one cutting edge. This knife was carried across the chamber, and was made to pass between the iris and the lens for a sufficient distance. The edge was then turned towards the cornea, and the iris was divided by cutting against the cornea as the knife was withdrawn. The slight incision which was sometimes made through Descemet's membrane, or even into

[1] [Mr. Critchett made the incision in the transparent cornea, whereas the German surgeons generally made it much further back, and in the sclera, a difference which may go far to explain their recorded bad results. Critchett's operation is not especially difficult of performance.]

the corneal tissue, is said not to have been productive of inconvenience; and the slit in the iris has been found to gape in a satisfactory manner. M. de Wecker, however, who approved of the radial incision in the iris, but not of the corneal wound, devised the scissors already shown in Fig. 66, and uses them instead of the knife. They are introduced at the same point and in the same direction, allowed to expand when they reach the pupillary margin, and then pushed on so as to include the iris between their blades, and to divide it as they are closed to be withdrawn. Of Mr. Bowman's operation I have no personal experience, nor have I seen any eye upon which it has been performed. M. de Wecker's method I have practiced in several cases, usually with fairly good results. But I regard it as being beset with difficulties and sources of danger for which there are no compensating advantages. There is much risk of wounding the anterior capsule and producing cataract; there is some risk of dislocating the lens. As the aqueous humor escapes, the iris rises against the scissor-blades and infolds them, so that it is not always easy to be sure that the posterior blade has really passed behind the margin of the pupil. M. de Wecker, who admits these difficulties, contends that they should be disregarded by the skilful surgeon; and I should be in absolute agreement with this view if there were anything to be gained by disregarding them. But the patients on whom I have performed iridotomy (as he calls this procedure) have not obtained much better sight than I should have expected from a small and well-placed iridectomy; and this being the case, I think that the risks attendant upon the former method require serious consideration. They are not to be entirely set aside by any amount of dexterity; because they may be dependent upon some action on the part of the patient which is beyond the control of the operator, such as some sudden movement of the head, or of the eye itself. A source of difficulty, in an eye operation, must necessarily be also a source of occasional failure; and I feel sure that any one who performed iridotomy a hundred times would have to regret the loss or serious injury of a certain (possibly very small) percentage of eyes, which would have been saved if iridectomy had been practiced upon them. In iridectomy we may almost say that there is no risk whatever, or at most a risk so small that it is scarcely numerically appreciable. On this ground alone, if on no other, I scarcely think that I shall be seduced from my allegiance to it by any new contrivances, however useful or ingenious they may at first sight appear.

Since the foregoing paragraph was written, and indeed while these pages were passing through the press, it occurred to me that M. de Wecker's scissors would afford a means of making an iridectomy for optical purposes in a simple manner, by excising a very narrow radial plait of the iris without drawing out that membrane. However small may be the opening through which an iridectomy is made in the ordinary way, the resulting coloboma will often be larger than the surgeon either expects or desires; and we have no means of limiting precisely the dimensions of the piece

excised, either as regards its breadth or its extent towards the ciliary margin. The power to cut a small V-shaped notch in the iris, a notch with its base to the pupillary, and its apex to the ciliary border, and to determine approximately the size of this notch, would often be useful in practice, not only in cases of central corneal opacity, but also in a form of cataract of which a description will be given in a subsequent chapter. I have succeeded in accomplishing this object in a few cases, by introducing M. de Wecker's scissors, with closed blades, through a very small opening immediately in front of the plane of the iris, and by suffering them to expand as soon as the blunt extremities of their blades reached the pupillary area. As the blades expand, an escape of aqueous humor lifts a plait of iris between their edges, and this plait is excised as they are closed. In the cases in which I have already operated, I have found no difficulty in withdrawing the bit of detached iris from the anterior chamber; but Messrs. Weiss are constructing for me a pair of special scissors for the purpose, furnished with minute teeth, and intended to hold and remove the piece as it is cut. It is necessary, of course, to be careful of the lens, and on this account, to direct the blades from the wound of entrance rather towards the centre of the cornea; but I am disposed to think that the danger of producing traumatic cataract will be less, by this method, than either by that of Mr. Bowman or of M. de Wecker, and also that it will be possible, after a little practice, to regulate the size of the plait of iris with much nicety. Until farther experience has been gained, it would be impossible to speak with any certainty concerning the practical advantages which may attend upon this mode of operating, or concerning the risks by which it may be beset. I mention it only for the sake of placing it upon record, and may probably publish the results of a larger number of operations on some future occasion.

Whatever method of making an artificial pupil is selected, it may generally be put in practice before the cornea has attained its ultimate degree of restoration to transparency; and hence, when the eye has fully recovered from the operation, it is often desirable to persevere with treatment for the purpose of promoting the disappearance of corneal infiltration. To this end it is usual to employ stimulating applications, changing them from time to time; and perhaps mercurial ointments—especially Pagenstecher's ointment and Williams's citrine ointment—are the most generally useful. In severe cases I have continued for many months, at intervals of three or four weeks, the subconjunctival injection of the solution of chloride of sodium.

Whenever there is an opaque white cicatrix of a permanent character, the result of absolute loss of corneal tissue, it may be disguised by tattooing with Indian-ink, so that if central it may imitate the natural pupil, and if lateral it may at least cease to be an obvious disfigurement. This operation is often a great boon to domestic servants, and to various classes of artisans, with whom a conspicuous blemish in an eye may be a formidable obstacle to

procuring employment. The practice dates from very remote antiquity; but its modern use is quite recent, and is due to the fertile brain of M. de Wecker. Tattooing may be performed with any sharp-pointed instrument—and a common vaccinating needle, with a groove in the blade which will carry pigment in place of lymph, will be found to answer very well. For a large scar it is customary to use a little bundle of three or four sewing-needles, fixed together in a handle, so as to make three or four punctures at each thrust. An anæsthetic should be given, the eyelids held open by a speculum, the eyeball fixed, and the cicatrix covered with Indian-ink rubbed down with water to the consistence of thick cream. This is then to be pricked into the opaque tissue as in ordinary tattooing; and the ink may be wiped off with the tip of a finger from time to time, so as to uncover the scar for inspection and to show what progress has been made, and what portions have escaped the needles. Sometimes a single operation will suffice, sometimes it may be necessary to repeat the process on account of patches which are insufficiently colored. Whilst the punctures are being made, it is well to apply a morsel of sponge to the outer part of the margin of the upper lid, to absorb tears which would otherwise flow over the cornea; and the speculum should be left in place for a few minutes after the punctures are completed. The subsequent irritation is of the most trifling character, and the tattooing may be repeated in a week if repetition should be necessary. By this means a white scar may be so completely concealed as to be almost invisible except when the eye is seen in profile, and when, of course, the black deposit on its surface becomes apparent.

When an ulcer of the cornea has been of such extent and depth as to produce a complete staphyloma, the only object of the surgeon will be to enable the patient to wear an artificial eye to conceal the deformity; and then, in every instance in which there is any likelihood, or even possibility, of the presence of changes in the deeper parts which might produce sympathetic ophthalmia, it becomes necessary to enucleate the diseased organ as a whole, leaving a stump to be formed by its muscles. When this danger does not exist it is better to remain satisfied with the removal of the front portion of the globe. The posterior half or two-thirds of the eyeball will form the nucleus of a comparatively large and movable stump, on which an artificial eye can be placed with greater advantage than on one which is composed of muscles only.

In former times it was customary simply to cut off a corneal staphyloma, and to leave the rest of the eyeball to shrink and cicatrize in its own time. Mr. Critchett greatly improved on this method by the operation commonly called after his name. He transfixed the eyeball, behind the ciliary region, by two or three semicircular threaded needles, excised the portion in front of them, and then drew the needles through and tied their threads in such a manner as to unite the gaping wound in a horizontal line. The sutures passed through retina, choroid, sclerotic, and conjunctiva. The stumps obtained by this procedure are ex-

tremely good, and they present internal and external angular projections on behalf of which it is claimed that they afford to an artificial eye a hold of pecular excellence. I have practiced this operation many times, and with the best results.

Early in last year, however, a strong healthy agricultural laborer came to St. George's Hospital, with complete staphyloma of his right cornea, the result of a wound from a thorn, received while "hedging." The eye was lost as an organ of vision and the protrusion was unsightly. I performed Mr. Critchett's operation, and obtained a stump which appeared to leave nothing to be desired. The man returned to his home, but came back in a month or six weeks with advanced sympathetic ophthalmia of his remaining eye. Enucleation of the stump was immediately practiced; but the ophthalmia resisted all treatment, and ended in total loss of sight.

It is well known that the ordinary cause of sympathetic ophthalmia is irritation of a ciliary nerve. In this case it is possible that the irritation may have been due only to the traction of the cicatrix; but I think it more likely that a ciliary nerve was lacerated by one of the transfixing needles. Such an accident, although the chances are many that it will not happen, is one against which it is impossible to guard; and I therefore set myself to contrive a substitute for Mr. Critchett's operation, one which should avoid its risks, and which should secure all its advantages.[1]

For this purpose I now divide the conjunctiva with scissors, close to the corneal margin, and detach it from the subjacent parts nearly to the equator of the eyeball. I then take a squint-hook with an eye in its point, carrying a silk thread, and by this means I pass a separate ligature under each of the recti muscles in succession. I tie each ligature around the tendon under which it lies, about a line from its insertion into the sclerotic, and then divide each tendon at its insertion, so that I can still command the muscles by the ligatures attached to them.

The next step is to remove, in the ordinary way, as much of the eyeball as circumstances may require. This done, I take a needle threaded with fine carbolized catgut, and pass it through the tendons of the superior and inferior recti, just behind the ligatures. The ligatures are then cut and removed, and the two tendons are united in front of the gaping remains of the eyeball by tying the catgut suture. The external and internal recti are then united in a similar manner by a second catgut suture. The ends of the catgut sutures are cut off as closely as possible, and the last step of the operation is to unite the edges of the conjunctival wound in a horizontal line by three or four points of fine silk suture. In

[1] [The danger of sympathetic ophthalmia, after abscission of a staphyloma by Mr. Critchett's method, was recognized in 1867, by Knapp, who also ingeniously modified the operation so as to include only the conjunctiva and episcleral tissues in the sutures. See *Archiv für Augenheilkunde*, xiv, 1, pp. 273–7; also Soelberg-Wells, *On the Diseases of the Eye*, Third English and Second American edition.]

some cases the catgut threads cut their way out and are cast off; in others they remain and are absorbed; but this difference does not seem to affect the result. In any case the coats of the eyeball, except the conjunctiva, sustain no other injury than a clean incision, and are not dragged upon in any way, either during or after the healing process. The recti muscles become firmly united in front of the stump, so as at once to form a protective cushion over its surface, and to act upon it very advantageously as regards its movements.

The operation requires a minute or two more for its performance than that introduced by Mr. Critchett, but this does not constitute a serious disadvantage. It would be quite possible to dispense with the ligatures on the tendons; but they give complete and immediate command of the severed muscles, and the time spent in tying them is probably redeemed by the convenience of their presence.

When a staphylomatous eye is not painful, an operation upon it is only required for the purpose of removing a disfigurement; and such an operation, in adults, may be undertaken at any time. In young children, the diseased eye is apt to become much expanded, and it then produces corresponding expansion of the orbit in which it is contained, and permanent enlargement of the bones by which that orbit is formed. In order to avoid such an occurrence, it may be desirable to operate early; but, on the other hand, if a staphyloma is removed from a child who is too young to wear an artificial eye, the result may be a disfigurement of an opposite kind; inasmuch as not only the orbital bones, but also the eyelids and palpebral fissure, will be liable to fall into a state of arrested development, and to be permanently diminished in size. When an artificial eye can be worn, such an effect does not follow; but in other cases the liability to its occurrence sometimes leaves the surgeon only a choice between two evils. The earliest age at which a child may wear an artificial eye will depend partly upon its own intelligence, and partly upon the nature of its surroundings; but until this age is attained a staphyloma must not be removed unless it is either a source of pain and distress, or unless the enlargement of the eyeball is very considerable. As a general rule it is best not to operate upon patients who are less than eight or ten years old.

Besides the flattening or projection of the cornea which may be produced by the cicatrization of ulcers, the membrane is also liable to other changes of outline, due to inflammation or to atrophy. After some forms of interstitial or vascular keratitis, the whole cornea may become so much softened that it is rendered unduly convex or globose by yielding to the pressure from within. The conditions of flattening and of expansion are alike irremediable unless by optical means, and only seldom by these; because it is only seldom that the altered curvature is even approximately a surface of revolution, such as a lens can be ground to correct. The distortion arising from atrophy is the state known as conical

cornea, or keratoconus; and it is produced when the atrophy affects the central parts, either exclusively, or in a greater degree than the marginal parts. In old persons who are generally marasmic, it is not uncommon for the cornea to be atrophied as a whole; and the same thing occurs less frequently at an earlier period of life. But this change produces no distortion; and indeed can hardly be discovered until the support of the aqueous humor has been withdrawn by puncture or incision into the anterior chamber, when the thin and feeble cornea will collapse, and will present a flattened and wrinkled surface. But when atrophy affects the central region chiefly or exclusively, this region yields to the intraocular pressure and to the tension of the muscles, and becomes projected forward as a pellucid prominence, which, in declared cases, when seen from the front, looks almost as if a drop of bright dew were resting upon the centre of the cornea. When seen in profile it presents an irregular elevation with a rounded summit, which may perhaps be called conoidal, but to which, if language is to retain any scientific meaning, the word conical cannot be applied with propriety. The distortion of the cornea sometimes remains stationary at a given point, but in the majority of cases it slowly increases; and in time the summit of the projection, being imperfectly protected by the eyelids, is apt to become more or less roughened and turbid, a change by which the previous appearance of a pellucid drop is destroyed.

The occurrence of this deformity is attended, of course, by a certain degree of near sight, or myopia, due to the antero-posterior elongation of the eyeball. If the case were, indeed, as it is commonly called, one of conical cornea, it would be possible to correct this myopia, and to restore good vision by a lens with a corresponding depression.[1] But, instead of being conical, the projection is usually irregular. It has a rounded summit, which is seldom central as regards the whole membrane; and the sides, although they slope from summit to base, do not slope uniformly or symmetrically. Moreover, the projection is often greater in one meridian than in others, and hence no glass can be made to correct

[1] [In conical cornea the attendant myopia is usually enormous in degree, and is dependent almost wholly upon the extremely short radius of curvature of the rounded apex of the cone. Conjoined with this myopic refraction at the apex is the irregular refraction at the general surface of the cone; the whole giving rise to a confusion of rays which it is impossible to resolve by any combination of lenses, but whose disturbing effect upon vision may be reduced to a minimum, which is often compatible with tolerably acute vision, by looking through a small hole or narrow slit. Even if the cornea were truly conical in form, no lens could be of material service unless it were placed in contact, or nearly in contact, with the cornea, and could follow the eye in its movements. It is possible to conceive of an apparatus with a small artificial cornea, of proper curvature, which might be worn like an artificial eye, the space between the central portion of the true cornea and the artificial cornea being so adjusted as to admit of its retaining by capillary attraction enough of the tears to fill the space, and so virtually to correct the corneal curvature. In many cases of conical cornea in its lower and medium grades it is possible to accomplish a good deal by patient trials with various combinations of spherical and cylindrical glasses, and the effect of these may in some cases be increased by covering them in part with dark paint or paper.]

all the irregularities of the surface. The result is that the shortness of sight is combined with extremely defective vision; and that patients suffering from a high degree of the disorder may be regarded, for most of the aims of life, as being practically blind. They can neither read ordinary characters nor pursue ordinary occupations; and their state becomes worse and worse as the physical change which produces it becomes more declared. Whenever shortness of sight is increasing, and cannot be corrected by lenses, the cornea should be carefully examined for projection. In its advanced state the malady is at once apparent, but in its earlier stages it may escape observation if not specially looked for. Even before it is certainly recognizable in profile, it may be discovered in a manner which Mr. Bowman was, I believe, the first to make known. If the projecting cornea is examined with an ophthalmoscopic mirror the pupil no longer appears as a uniform and unbroken luminous circle. One half of the base of the elevation will lie in shadow; and this shadow will play about, from side to side, in response to slight movements of the mirror.

The true pathology of this affection, the thinning of the central parts of the cornea, has only recently been made known;[1] and the treatment in former times was chiefly by optical appliances tried almost at haphazard. Some patients were assisted by looking through narrow slits in metal plates—others by looking through small circular openings. Thirty years ago, many cases were treated by what was then called the "emeto-purgative" plan. The unfortunate victims were advised to swallow an emetic, and after its action a saline purgative, every day for a twelvemonth. It was stoutly maintained that much improvement of sight had attended this method; and I am almost sure that I remember a controversy, in the medical journals of that day, about the person to whom the merit of having suggested it was really due. Tried by the test of time, it fell into desuetude; and the next device was a surgical one—namely, to make an artificial pupil behind some lateral and less distorted part of the cornea. In this way a certain degree of improvement was often obtained; more especially as the excision of a portion of iris would diminish the general tension of the globe, and would thus also diminish one of the causes of the increase of the malady. But the new pupil, although not behind the summit of the projection, was still usually behind a portion of cornea which was more or less distorted, and through which no really good vision could be obtained.

It has already been said that in some cases (those in which there was a lesser degree of distortion in some one meridian) benefit was derived from looking through a slit-like aperture in a metal plate, when the slit was placed in some particular position. Soon after Mr. Critchett introduced his operation of iridodesis, Mr. Bowman suggested that by its means the pupil itself might be converted

[1] [It was distinctly stated by Wardrop that the apex of the cone is often of extreme thinness: Jäger and Middlemore observed the same thing in conical corneæ, which they dissected.]

into a slit-like aperture; and he accordingly ligatured the iris at two opposite points of the corneal circumference, selecting them by trial of the best position for the slit in the metal plate. Improved vision was undoubtedly in some cases obtained; but the resulting pupil was not very satisfactory. It always had a distinctly elliptical outline, gaping in the middle sufficiently to admit rays which had passed through every part of the summit of the corneal projection; and the eventual risks of a double iridodesis were not to be lightly encountered. The method was for a time much practiced; but, even if it had not been superseded, I doubt whether it would long have held its ground.

A sound and scientific basis for the surgical treatment of conical cornea was first laid down by Von Graefe. He had observed the flattening of the natural cornea which is so often produced during the healing of an ulcer, and he determined to bring the same action to the cure of the deformity. In his first experiments he shaved off a small portion of the surface of the summit of the projection, and touched the exposed corneal tissue, every second or third day, with diluted solid nitrate of silver, so as to produce an ulcer with a sloughing surface. When he thought the ulcer large enough to produce the desired effect, the caustic was discontinued, atropine and a compressive bandage were applied, and the process of repair was encouraged. When cicatrization was complete, the surface of the cornea was carefully explored for the portion which approached most nearly to the natural curvature, and behind this portion an artificial pupil was made by iridectomy. The results were eminently satisfactory; and several persons were restored to a degree of vision which was not, indeed, perfect, but which permitted them comfortably to follow industrial occupations.

The operation of shaving off the apex of the projection is a difficult and delicate one, and the surgeons who attempted to follow Von Graefe's practice frequently opened the anterior chamber with the knife. After a time, it was found that the cases in which this accident had happened did quite well; and eventually the fact was recognized that a simple abscission of the apex, without any use of caustic, would answer every purpose. The operation now chiefly practiced is to cut off the summit of the prominence and to leave the wound to heal. Different instruments, such as small trephines, or knives of various shapes, have been employed by different surgeons; but I have found nothing more useful than a narrow iridectomy knife, with both its cutting edges as keen as possible. The point may be made to transfix the summit, and as the knife is pushed on its sides will complete the excision of the portion of cornea which remains in front of the blade, and which, if left partially attached, may be completely removed by scissors. The opening into the anterior chamber should not, at the outside, be a line in diameter, and should seldom exceed half a line. Prior to the operation, the pupil should be brought fully under the influence of atropine, by instilling a drop of a four-grain solution twice or thrice a day for a day or two. As soon as the excision is com-

pleted the lids should be closed and covered with a compressive bandage; and extract of belladonna, diluted with glycerine to a proper consistence, should be applied on the brow and temple, to maintain the dilatation and to keep the pupillary margin away from the wound. If the eye is comfortable, and if the lids remain free from swelling, it is better not to open them for three or four days, and the compressive bandage and the belladonna may be renewed daily, without any examination of the wound. If heat or swelling should occur, the local application of cold, or of leeches, or both, may be necessary; and the lid should be carefully raised, so that the precise condition of the eye may be ascertained. If all goes well, the wound will become firmly cicatrized after a time; and a cornea of apparently normal curvature, but disfigured by a central white opacity, will be the result. The pupil must then be once more fully dilated, and a small iridectomy performed, by one of the methods already mentioned, behind that portion of clear cornea through which the best definition of small retinal vessels can be obtained. Finally, the central cicatrix, when a sufficient time has elapsed, may be tattooed with Indian-ink, and thus rendered invisible to a casual observer.

The result of this procedure, in favorable cases, is the cure of the deformity, and the restoration of something which approaches very nearly to normal vision. There can be few greater triumphs of surgery than these cases; but the frequent realization of such benefits must not render us forgetful that the treatment may have two issues. There must be some cause for central atrophy of the cornea, some cause, that is to say, lying deeper than the cornea itself; and this cause may retard or prevent the healing of the wound, or may possibly be the source of new and formidable troubles. I have already mentioned having seen one case in which the operation, performed by another surgeon, had been followed by distressing pain and long-delayed healing; insomuch that the patient, when at last the proper time arrived, refused to submit to the iridectomy without which she could not benefit by the altered state of her cornea. Possibly some nerve filament was entangled in or irritated by the cicatrix, for the pain continued after healing was complete, the tension of the eyeball steadily increased, and sight was at last wholly destroyed by glaucoma. In one of my own cases, the patient, who was under ether, gave a sudden and violent sneeze, without the slightest warning, at the time when the point of the knife had entered the anterior chamber, and before the counter-puncture had been made. The result was the excision of too large a piece of cornea; and hence the slow formation of a large feeble cicatrix, to which the pupillary margin became adherent at one or two points. The cicatrix is too large to admit of really good vision by the side of it, and too thin and weak to admit of being tattooed completely. I hope eventually to conduct this case to a moderately successful termination; but at present very little has been gained. In young and healthy patients, and particularly when the distortion is stationary, I

should never hesitate to perform the operation; but in feeble or elderly persons, or in persons with a diathesis, or when the projection was increasing, especially if one eye remained tolerably useful, I should hesitate to interfere unless compelled to do so, and should even then endeavor, as a preliminary to operating, to improve the general health in every possible way. Of course, if a patient either is, or is rapidly becoming so far blind that he can hardly be made much worse, it is necessary to give him the chance which the operation may afford, and to encourage hopefulness by doing full justice to the prospects of success. But in no case should a good result be stated to be even approximately sure; and in no case should the treatment be undertaken without full knowledge, on the part of the patient as well as on that of the surgeon, that it may be somewhat protracted in its duration, and that it is very uncertain in its results.

CHAPTER IX.

DISEASES OF THE IRIS, INCLUDING IRIDO-CHOROIDITIS AND SYMPATHETIC OPHTHALMIA.

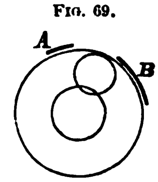
THE diseases of the iris, although neither numerous nor complicated, are second to no others in their importance, in the frequency with which they occur, or in respect of the irreparable injury which may arise from neglect or maltreatment of them. The membrane is liable to certain congenital malformations; such as the state called coloboma iridis, in which a gap or fissure of variable magnitude extends from the pupillary margin towards or to the periphery, or may even be continued through the ciliary body and the choroid; or such as the persistence of portions of the membrane by which the pupil is closed during fœtal life. In such cases there is generally more or less defect of vision, not necessarily dependent upon the malformation, but frequently only one result of the imperfect development of which the malformation is itself an evidence. Coloboma is irremediable, and could not be mistaken for any other condition except that produced by an iridectomy, which it sometimes almost precisely resembles. Persistent pupillary membrane is very rare; insomuch that I have seen only two examples of it. Professor Alfred Graefe has recorded an instance in which the persistent membrane was complete, except that it was pierced by several apertures, or small pupils; but in the cases which have fallen under my own observation the remains have been filamentous only. Fig. 3, page 25, is a portrait of one of these cases, taken when the dilated pupil was lighted up by the mirror of an ophthalmoscope; and it shows

a condition which might possibly be mistaken for a line of opacity in the lens. The attachments of the filament to the iris could, however, easily be made out by careful examination; and its anterior surface, when seen by focal illumination and magnified, was of the same brown color and velvety aspect as the surface of the iris itself. The bifurcation of the filament at its upper extremity was very remarkable; and in the left eye no similar remains existed. The patient was a boy of nine years old, with a high degree of hypermetropia and amblyopia, and the subject of an enormous congenital enlargement of the spleen, a condition which had existed in his father, and which his sister had also inherited. These malformations are of little practical interest or importance, and can only be regarded as surgical curiosities. It is conceivable that a case might exist in which a persistent pupillary membrane might interfere with vision, and might require removal or the performance of an iridectomy; but I am not aware that anything of the kind has been recorded.

The iris is occasionally the seat of cystic or other tumors, which, if they are either actively growing, or if they interfere with vision, should be removed while they are still small, together with the portion of iris from which they spring. Many attempts have been made to destroy cysts by puncture, or even by very free laceration with cataract needles; but in such cases they have usually refilled, and have often increased more rapidly after the treatment than before. Solid tumors are very rare, and a case of round-celled sarcomata of both irides, which I brought before the Clinical Society, and an account of which appears in the seventh volume of their *Transactions*, is, as far as I am aware, unique.[1] When a tumor or cyst is attached to the iris, there may be some difficulty in making an incision into the anterior chamber sufficient for the removal of the growth, without at the same time wounding it; and this difficulty, in the case referred to, I succeeded in overcoming in the following manner: I took two very narrow iridectomy knives, one of which was blunted at the sides to the extent shown by the dark lines in Fig. 68. This was thrust into the anterior chamber, in the sclero-corneal junction, with the left hand, on the left side of the growth, as shown by the line A in the diagram (Fig. 69). It was retained in its position, so as both to retain the aqueous humor and to serve as a fixation instrument (care being taken that it did not touch the tumor), while the second knife was entered by the right hand at B, on the right-hand side of the tumor, and was

FIG. 68.

FIG. 69.



[1] [Cases of sarcoma of the iris are described by Lebrun (*Annales d'Oculistique*, 1868), Hirschberg (*Archiv für Ophthalmologie*, 1868), and Roosa (*Trans. Am. Oph. Soc.*, 1869). Cysts of the iris are not very rare, syphilitic gummy tumors are common, and cases of vascular tumor, simple pigment tumor, and of granulation tumor, have been described by trustworthy authors.]

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made to enlarge its incision as it was withdrawn. The first knife was also withdrawn; and then a Weber's canaliculus knife (Fig. 62, page 201) was introduced at incision B, its blunt extremity being kept in contact with the inner surface of the cornea, and insinuated between the cornea and the growth until it emerged through incision A. The edge was then turned towards the sclero-corneal junction, and the two incisions were united by a gentle sawing movement. A blunt hook was next passed into the anterior chamber, and the tumor, together with the piece of iris on which it rested, was drawn out to be excised by scissors. In this particular case the character of the growth rendered the operation of no avail; but the method pursued is one which may be useful in more favorable cases.

The disease of the iris which more than any other demands attention is inflammation. Iritis is an extremely common affection, which is liable to occur at all periods of life, even from the intra-uterine to extreme old age. Its possible causes are various; its common causes are injury, some dyscrasia, such as syphilis or rheumatism, and also, I think, some forms of perverted innervation. It is often referred to an exciting cause, such as overwork of the eye, exposure to cold, to glare, to irritating particles or vapors; but these conditions, when they are not sufficiently intense to be included within the general term "injury," probably owe their efficacy entirely to the presence of some predisposing influence. Iritis is seen under two principal forms,—the plastic and the serous. In plastic iritis there is a considerable exudation of lymph, which sometimes forms nodules on the surface of the membrane, or at the margin of the pupil, and which tends to produce adhesions of the iris to the anterior capsule of the lens. In mild cases which are not subjected to any external irritation, the tendency of iritis is towards recovery; but this recovery, unless guided and assisted by suitable treatment, will leave the already mentioned adhesions permanently established. In cases originally severe, or which have been subjected to irritation, the iritis may pass into a chronic form, or it may extend to the ciliary body and the choroid. In the latter case it is usually followed by great impairment or even total loss of vision, and sometimes by an extension of the disease to the other eye. In serous iritis the effusion consists of turbid fluid rather than of lymph, and has little or no tendency to tie down the pupil to the lens. But this fluid augments the tension of the eyeball in a very decided manner; and the increased tension mechanically obstructs the circulation in such a degree that repair is scarcely possible until diminution of pressure has been brought about by mechanical means.

The diagnosis of iritis need never be a matter of doubt to any person who will take the trouble to examine the affected eye carefully. I have mentioned in a former chapter the case of a gentleman in whom spasmodic contraction of the pupil, with a general sense of dragging and discomfort in the eye, preceded an outbreak of acute iritis by a few hours; and I believe that such a preliminary

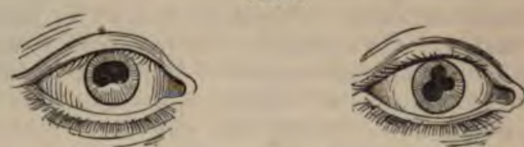
nervous stage is of no uncommon occurrence. But people who feel only a little discomfort in one eye will usually wait a day before they seek medical advice; and a day, under such circumstances, is sufficient greatly to alter the aspect of affairs, and to present the malady in a developed form. The first symptoms by which iritis can be distinctly recognized are four in number, and they are usually all present at once. They are—1, a slight diminution of the ordinary lustre of the surface of the iris, with some apparent change in its color; 2, some degree of impaired mobility of the pupil; 3, some impairment of vision; 4, a slight zone of pericorneal sclerotic congestion. If only one eye is affected, the other may be used as a standard of comparison; and, in testing the mobility of the pupil, the sound eye must be screened from the light, and the affected eye alternately shaded and exposed without being touched. A deceptive resemblance to iritis may occasionally be produced by some affections of the cornea; for a hazy cornea may at the same time conceal the lustre of the iris, diminish its mobility by diminishing the quantity of light which reaches it, impair vision, and be attended by sclerotic congestion. The removal of any doubt hence arising may be obtained by the application of a four-grain solution of atropine. If this fully dilates the pupil within the customary time (twenty minutes or so), and if the dilated pupil preserves a circular outline, iritis is certainly not present. Generally speaking, even when the patient is seen for the first time, one or more points of adhesion will have formed, and atropine, if it dilates the pupil at all, will dilate it into an irregular outline, which at once renders the adhesions conspicuous. Fig. 70 shows iritic adhesions [as seen with the ophthalmoscope], with the pupil dilated in the intervals between them. This portrait was taken partly on account of the remarkable (and very unusual) symmetry with which the adhesions are arranged round the pupillary margin; partly because the patient was a girl only ten years old, at which age iritis is of comparatively rare occurrence; and partly because the symmetry of the dark lines gives them some degree of resemblance, when seen with the ophthalmoscope, to the striæ of commencing cataract. As a rule, the adhesions are placed irregularly; and atropine, if it acts at all, produces some such outline as one of those shown in Fig. 71. If more time has elapsed since the commencement of the disease, and if the case was either severe originally, or has been rendered so by maltreatment, the pupil may be wholly immovable, either universally adherent or totally insensible to the action of atropine,

FIG. 70.

Symmetrical adhesions left by iritis (viewed by the aid of the ophthalmoscopic mirror).

the surface of the iris may present bloodvessels visible to the naked eye, the anterior chamber may be more or less filled with lymph, partly adherent to the iris, partly diffused through the aqueous humor, and sometimes passing into a purulent condition,

FIG. 71.



vision may be reduced to qualitative perception of light, and the ocular conjunctiva may be intensely congested.

Pain is a very uncertain symptom. It is nearly always present when there is increased tension; but in other cases it seems to depend more upon the condition of the patient than upon that of the eye. When there is pain, there is nearly always constitutional disturbance—either feverishness and a loaded tongue, with disordered secretions, or else a generally neurotic state, the pain ramifying more or less through the different branches of the fifth nerve, and often assuming an intermittent or paroxysmal character.

Intolerance of light is seldom present; but, when present in any marked degree, it is a symptom of grave import.[1] It indicates at least a tendency on the part of the ciliary body, to participate in the morbid action; and it gives to the whole case an entirely new significance.

In the treatment of iritis, in all its stages, forms, and varieties, the first principle to be borne in mind, and to be acted upon in every case without exception, is a negative one. It is to avoid all irritants. The worst cases which present themselves at hospitals are those in which the inflammation has been "treated" for a day or two, by nitrate of silver drops or zinc lotion. Such applications are occasionally prescribed by medical men who mistake the condition for inflammation of the conjunctiva; but more often the astringent has been either the gift of some monthly nurse or midwife, or an outcome of the proceeding which is commonly described as "counter practice." It is much to be wished that all persons, who may by any possibility be tempted to prescribe for eye disease without knowing anything about it, would at least lay to heart the cardinal truth that a solution of atropine, although it may fail to do good, will in many cases be very serviceable, and can scarcely ever do any harm. Astringents, on the other hand, although highly conducive to the cure of conjunctival affections, may be productive of irreparable mischief when either the cornea or the iris is inflamed. A commencing iritis treated

[1] [In rheumatic iritis of only moderate severity we sometimes meet with cases of very acute pain on exposure to light.]

by a nitrate of silver lotion, is apt to be stimulated into a state of intensity which is hardly ever seen under any other circumstances.

It has already been said that (in a case which is not traumatic) the tendency of a plastic iritis of only moderate severity is towards recovery. Whenever this tendency is present, the indications of treatment are only two—first, not to thwart the tendency; next, to prevent the formation of adhesions, or to overcome them if they have formed already. For the fulfilment of the first indication it is necessary to give both eyes complete functional rest, and to protect them from changes of temperature, from irritants, and from glare. Hence, reading and writing, or any analogous employments, should be prohibited, and in bad weather the patient should be confined to comfortable rooms, into which only a moderate degree of illumination is admitted. In fine and warm weather he may go out, but the eyes should be screened by an ample shade, or by large blue spectacles so arranged as to intercept lateral as well as direct light. When circumstances do not admit of these precautions being fully observed, and especially in the case of those who are compelled to be out of doors in bad weather, the sound eye should be used as sparingly as possible, and the affected eye should be covered by a compress of cotton-wool. In order to retain this compress in place a very convenient apparatus may be used, which is made and sold by Messrs. Carpenter & Westley, of No. 24 Regent Street. It consists of a little shell or cup of wire-gauze, shaped to fit the margin of the orbit, covered and bordered by black silk, and retained in its place by an elastic band which surrounds the head.[1] The cup will retain and conceal enough cotton-wool to keep the eyelids closed and at rest, and effectually to protect the eye from external cold; so that it forms a substitute for the compressive bandage. The patient should usually be placed upon a sufficient but unstimulating diet, a gentle laxative should be administered if necessary, and the action of the skin and kidneys should be encouraged by appropriate means. The fulfilment of the second indication is to be accomplished only by atropine; and hence the effectual use of atropine is the cardinal point in the treatment of iritis—the one thing which should never be omitted, save in the excessively rare cases in which it produces local inflammatory action. A reference to Figure 1, page 19, will show that the inner circle of the iris, when the pupil is of its ordinary diameter, rests in contact with the anterior surface of the capsule of the crystalline lens. In this position, the effusion of lymph is followed by the immediate adhesion of the structures between which it is interposed. But full dilatation of the pupil removes the iris from its contact with the lens, in consequence of the receding curvature of the marginal parts of the latter. The anterior capsule is then separated from the iris by a film of aqueous humor, into which the lymph pro-

[1] [A pair of ordinary wire "goggles," which are held in place by an elastic strap, will answer, filling one of the cups with soft cotton.]

jects without becoming adherent, or through which it is diffused. Complete dilatation of the pupil, therefore, presents an insuperable physical obstacle to the formation of adhesions; and, as soon as the pupil is completely dilated, there is nothing more to do than to maintain the dilatation, and to suffer the iritis to die out harmlessly. A great many pages of paper have been covered with printed characters for the purpose of showing that the dilatator muscle of an inflamed iris is necessarily paralyzed by the inflammation; and hence that atropine cannot act upon the pupil whilst iritis exists. Any controversy upon these questions must be a verbal one, which must turn only upon what the words inflammation and iritis mean; for the clinical facts admit of no dispute. A four-grain solution of atropine, when applied to a healthy eye, produces complete dilatation of the pupil in less than half an hour. When applied to an eye presenting the appearances which have already been described as characteristic of the commencement of iritis, the dilatation is produced more slowly; and perhaps does not become complete until after three or four applications, with intervals of an hour between them. When the iritis has already existed twenty-four or thirty-six hours, the atropine will only produce irregular dilatation—the pupil expanding fully in some directions, while its margin is fixed at certain points by adhesion to the capsule of the lens. The atropine being continued, the recent adhesions will in many cases give way; and when they do so the dilatation becomes complete. The atropine being still continued, the eye may recover in the course of a few days, and then the pupil may be suffered to return to its normal diameter. Complete dilatation is always attended by much relief to the symptoms previously complained of by the patient; but if atropine is laid aside as soon as complete dilatation is produced, the improvement will often be only temporary. The pupil contracts again, the hyperæmia continues or increases, more lymph is poured out, and adhesions recur; facts in natural history which may be seen every day in the out-patient department of any ophthalmic hospital, in the cases of patients who neglect their instructions as soon as they feel better. The truth is, probably, that apart altogether from adhesions, a certain severity and duration of iritis may paralyze the dilatator muscle; but that the initial phenomena of the disease affect the connective tissue rather than the muscular fibres, leaving the latter free to respond, although less quickly than usual, to the stimulus of the drug. It is at least certain that atropine does dilate the pupil in cases for which no other name than iritis has been suggested, and in which the withdrawal of atropine is immediately followed by a return of the original symptoms. There can be no doubt, moreover, that dilatation of the pupil not only prevents the formation of adhesions, but that it also exercises a remarkable control over the morbid process, probably by the action of the atropine, through the sympathetic nerve, upon the vessels of the inflamed part; and hence, in [nearly] every case which is seen tolerably early, and in which

complete dilatation of the pupil can be produced in twenty-four hours, we may trust to atropine alone for the completion of the cure. A drop of the four-grain solution should be placed within the lower lid in the usual manner, repeated after five minutes, and again after another five minutes; and this threefold application should be repeated three times a day. As soon as complete dilatation is produced, a single drop may be applied night and morning, and continued until all unusual vascularity has disappeared, until the media are clear, and until natural vision is restored. In judging of the latter point it must be remembered that atropine paralyzes the accommodation, and that any indistinctness of vision hence arising may be removed by a convex lens of sufficient power. When recovery is apparently complete, the atropine may be laid aside, but the eye must be carefully watched for the first few days, and the slightest blush of congestion calls for an immediate return to the remedy. When iritis has existed for a day or two before treatment is commenced, we not unfrequently find cases in which one or two points of adhesion resist atropine; but we may still rely upon it, to the exclusion of other means, if the portions of iris between the adhesions dilate to the fullest extent which these mechanical impediments will allow. In such instances the adhesions may still remain after recovery is in all other respects complete; but the consideration of the treatment which they will then require must be deferred until other matters connected with the acute stage have been discussed.

When plastic iritis is of a high degree of original severity, or when it has been aggravated by improper treatment, or has been suffered to exist for some days unchecked, a state is produced in which atropine fails to exert its customary influence. Either the dilatator muscle is paralyzed, or the greater part of the pupillary margin is adherent, or these conditions coexist. The adhesions remain unaffected, and the intermediate portions of the pupil will only dilate partially and sluggishly, if at all, showing that the muscular fibres do not act, even where the margin is free. In such conditions the demand for mercury is imperative; and its constitutional action must be obtained as rapidly as prudent administration will allow. In hospital practice among out-patients, who are seen only twice a week, I find it sufficient to prescribe atropine drops for cases of iritis which are at once mild and recent. But if, when the patient is first seen, the attack has been running on for a day or two, and is even moderately severe, I prescribe mercury as well as atropine, giving perhaps two grains of blue-pill twice a day. When the patient again presents himself, if the pupil is well dilated, the mercury is laid aside; but if the pupil has resisted dilatation the mercury is pushed, with the knowledge that the quantity already taken has laid the foundation of the effect which it is desired to produce. This effect should not exceed the formation of the slightest mercurial line upon the gums; and it should be maintained until resolution of the inflammation is accomplished. The manner of administering mercury has been so fully discussed

in a preceding chapter that it is unnecessary to repeat what has already been set down with regard to it; and it is sufficient to say that the influence of the drug upon iritis is of the most marked and striking character. Improvement usually commences almost simultaneously with the first appearance of affection of the gums; and absorption of the effused lymph often proceeds with great rapidity. As the lymph disappears, the pupil yields to the atropine; and in the great majority of cases recovery is quickly brought about.

The influence exerted upon iritis by mercury, and the necessity for administering it in certain cases, seem to me to be essentially independent of the syphilitic or non-syphilitic character of the affection. The question is involved in some obscurity, because the diagnosis of syphilitic iritis is not quite so easy as it is sometimes represented to be. Many writers have described peculiarities which, in their judgment, prove an iritis to be syphilitic; but the descriptions differ so greatly that the syphilitic iritis of one author would be the non-syphilitic of another. I do not know of any proof that every iritis occurring in a syphilitic patient is necessarily syphilitic in its origin; or, in other words, I do not know that syphilis affords any immunity from the forms of iritis which may attack non-syphilitic people. I have seen iritis which I had every reason to think syphilitic yield readily to atropine alone; and I have seen iritis which I had every reason to think non-syphilitic resist atropine, and yield only to mercury. A patient who has iritis may also have syphilis, and may require mercury on account of that syphilis; but, speaking with reference to iritis alone, I do not even take into consideration, as a question bearing upon treatment, whether the iritis is syphilitic or not; but I accept resistance to atropine as the one sufficient proof that mercury is needed. Nor can I believe that the rapidly beneficial action of mercury affords, in itself, any conclusive evidence of syphilis. I have more than once mentioned Dr. Anstie's opinion that mercury possesses some special power, poisonous as well as remedial, over the parts supplied by the trifacial nerve; and that its power over lymph effused into the anterior chamber of the eye is greater than its power over lymph effused (say) into the pleura. I am inclined to think that this view may hereafter be established by a sufficient accumulation of evidence, and that the effect of mercury upon iritis may be shown to be due to the textures affected, rather than to any morbid poison or diathesis underlying the disease. It is a perplexing element in the question that iritis will frequently commence in persons who, at the very time, are actually under the influence of mercury for the cure of syphilis; and in these cases we have no resource but atropine, supplemented by such other means as the special symptoms or complications may suggest.

It sometimes happens that iritis is attended from the first by an unusually active degree of vascular excitement. The face will be somewhat flushed, the eyelids hot, the temporal pulse increased in fulness and force. Under such circumstances the action of atropine will be resisted; but it does not follow that mercury will be

required. Before having recourse to it, an effort should be made to subdue the vascular excitement, and, if this can be accomplished, complete dilatation of the pupil will often follow. I can conceive cases of this class in which it would be proper to take blood from the arm; but I have never met with one in which such a proceeding was necessary. I have often employed a leech or two to the temple, near the margin of the orbit, and have followed this local depletion by the application of local cold, both with excellent effect. Whenever there is evidence of active congestion, coupled with resistance to atropine, some form of depletion should precede the administration of mercury, and, if the pupil then becomes dilated, should supersede it. If there were any strong reason for abstaining from depletion, it might be worth while to give a minim or two of tincture of aconite every fifteen minutes, until a manifest depression of the pulse was obtained.

When iritis is accompanied by pain, this may arise from either of two widely different causes, and may assume either of two widely different characters. It may be the pain of hyperæsthesia, of nervous exaltation or irritation, or it may be the pain of tension, due to the stretching of the ocular tunics by increased secretion within. The former is usually more or less neuralgic and paroxysmal, the latter is usually described as a permanent sensation of fulness, stretching or weight. But verbal descriptions of pain have no common measure; and whenever pain is experienced in iritis the state of tension of the eyeball must be carefully and frequently examined, and must be diminished, if necessary, by paracentesis or by iridectomy, according to circumstances which will presently be considered. Pain of an irritative or neuralgic character must be subdued; for it may safely be laid down as a general principle that no improvement can be looked for whilst such pain continues. The best means of subduing it is generally by the hypodermic injection of a sufficient dose of morphia; and I am accustomed to make provision for a repetition of the dose, or of some smaller one, at intervals of every hour or every two hours, either hypodermically or in some other manner, until the desired effect is produced. Mention has been made in a former chapter of the late Mr. Lawrence's reliance upon morphia alone in iritis; and although I cannot share this reliance, I still regard the drug, or some equivalent to it, as an indispensable adjuvant when the disease is attended by pain. For mere insomnia, the hydrate of chloral may be employed, but as against pain I have not found it efficacious, unless in larger doses than it is generally desirable [or safe] to administer.

The pain of increased tension is almost peculiar to "serous" iritis, which differs from the more common form of the disease in the fluid character of the inflammatory effusion. Serous iritis is comparatively rare; and I have chiefly seen it associated with some grave disturbance of the general health, such as that produced by syphilis, or by imperfect action of the kidneys. The absence of plasticity in the diseased product may probably itself be looked upon as evidence of impaired nutrition. In its general symptoms

the malady at first resembles ordinary iritis. There is the same dulness and changed color of the iris, the same sluggishness of the pupil, the same zone of pericorneal vascularity, the same impairment of vision. Even in an early stage there is discoverable increase of tension; and atropine (possibly because the overfilled state of the eyeball interferes with absorption) produces only a slight dilatation of the pupil, which, however, retains its circular outline. As the case proceeds, the iris is seen to be somewhat pushed back, or rendered concave, by the distension of the anterior chamber; but before long, the fluid occasioning this distension may become too turbid to allow a very precise examination to be made. At the same time the surface of the cornea is frequently affected, and looks steamy, or as if it had been breathed upon, by reason of disturbance of its epithelium. Tension steadily increases, tensive pain is usually severe, and vision is impaired in a greater degree than the turbidity of the altered aqueous humor will explain. Sometimes, when the case has been seen quite at its commencement, and atropine has been applied, full dilatation of the pupil may be obtained, and afterwards preserved, but without improvement in the general condition; the obstructed circulation presenting an insuperable obstacle to the progress of repair. The remedy for such a state of things is paracentesis of the anterior chamber; and a single evacuation of the aqueous humor and its suspended inflammatory products, if performed early, will often be sufficient. In practiced hands, any sharp-pointed cutting instrument will suffice for the puncture, and any probe or bodkin for opening it to allow the fluid to escape; but a surgeon unaccustomed to eye operations will do well to use the stop paracentesis-needle shown in Fig. 65, page 227, which cannot enter the eye far enough to inflict any injury upon either lens or iris. The probe commonly placed at the other end of the handle of this needle is often too big and too thick at its bulbous extremity, so that it fills and plugs the puncture instead of opening it. I prefer a probe without a bulb, and with a longitudinal groove along which the aqueous humor may flow, or with a flat extremity, which may be turned a little on its axis so as to separate the lips of the wound.[1] The puncture should generally be made on the temporal side, and always just beyond the corneal margin, in order that it may not leave a visible scar; and the whole of the fluid contents of the chamber should be permitted to drain away. The little operation is so trifling that [except in very nervous patients] it requires neither an anæsthetic nor an assistant, and it may be performed at any time in the consulting-room. Notwithstanding the smart of the puncture, it is often productive of immediate and great relief to the uneasy sensations which were previously complained of; and it usually restores the natural tint of the iris, thus showing the apparent discoloration to have been due only to the turbid fluid through which the membrane was seen. At the next visit the tension must be examined and the

[1] [The ordinary Daviel's curette, Fig 83, page 316, answers perfectly.]

paracentesis repeated if necessary; and sometimes it will need repetition again and again; the wound being reopened with the blunt probe, or with the needle or other sharp instrument, according to the time that has elapsed since the last operation. But if serous iritis has existed for some time, and has produced very high tension with great impairment of sight, and especially if the patient resides at a distance from the surgeon, so that he cannot be seen frequently, it will be unsafe to trust to paracentesis, and necessary to have recourse to a more radical treatment by iridectomy. I was once called fifty miles from London, to a young gentleman of rheumatic diathesis, and with latent kidney disease which a few months afterwards became developed into fatal mischief, who had been suffering from serous iritis of one eye for about three weeks. The globe was of almost stony hardness, and vision was reduced to qualitative perception of light. I immediately excised a large piece of the iris; and the eye recovered without any other treatment. When the patient visited me a few weeks afterwards, I found that the stretching to which his eyeball had been subjected had so elongated it as to produce myopia $= \frac{1}{24}$. If he had been past middle life, with a less yielding sclerotic, there can be little doubt that he would have been irretrievably blinded by the compression of the retina. In operating upon such a case it is desirable to use a linear instead of a lance knife, and to keep the blade entirely above the region of the pupil. Although the lens and iris are usually pushed back, and the anterior chamber is rendered abnormally capacious, so that there is no difficulty in introducing a triangular blade to a sufficient extent, yet as soon as the incision is made, the aqueous humor is apt to be ejected with some force by the previously stretched tissues, and the lens might thus be thrown against the point of any instrument. When tension is once effectually relieved, the general treatment of serous iritis calls for little remark. It never requires mercury (although this may be necessary for the cure of some associated constitutional state) and seldom opium. The use of atropine should be continued until all inflammation has disappeared, functional rest must be as strictly as possible enforced, and the general health should receive careful attention.

Returning now to plastic iritis, we find a certain proportion of cases in which adhesions have been formed before treatment is commenced, and in which atropine, either with or without mercury, fails to detach them. The parts of the pupil which are intermediate between the adhesions dilate, but the adhesions themselves remain; and with this exception complete recovery takes place, with entire restoration of vision. An eye which is left in this state is not to be looked upon as cured; for although in a few instances no further mischief may ensue, yet in the majority the adhesions will become exciting causes of recurrent inflammation. As a rule, the eye in which iritis has left a partially adherent pupil will suffer from iritis again.[1] The function of the

[1] [Recurrence is also frequent in cases in which no adhesions have been formed.]

muscles of the iris is to alter the diameter of the pupil in response to every variation in the quantity of light which falls upon it; and an adhesion is a perpetual obstacle to the discharge of this function, and serves to check the variation of the pupil abruptly, whenever it passes a certain limit. As an almost necessary consequence, the adhesion becomes a source of irritation, and maintains a condition of preparedness to inflame. Accidental injury, overwork, or general disorder of the health, finds in the affected iris a part in which the natural vital resistance of the tissues is diminished, and in which morbid action is readily set up. The second attack of iritis, under these circumstances, falls upon an eye in which there is a mechanical impediment to the dilatation of the pupil, so that the parts of its margin adjacent to the existing adhesions must remain in contact with the capsule of the lens, and are thus liable to be rendered adherent themselves. Under judicious treatment, the second attack will generally subside, but not until it has added to the evil consequences left by the first. When one recurrence has taken place, others are almost certain to follow; and each binds down more and more of the pupillary margin, until at last this becomes entirely adherent, and there is no longer any communication between the anterior and the posterior chamber. This state is called, not very felicitously, "exclusion" of the pupil; and before it is produced there is usually a good deal of lymph deposited over the anterior pole of the lens, and this lymph, as it undergoes shrinkage, drags the pupillary margin together and assists in closing the opening. As long as the pupil is not entirely "excluded," as long as there is an aperture even the size of a pinhole, the case may be amenable to treatment; but as soon as the pupil is entirely closed a fresh series of changes will commence. The quantity of fluid contained in the anterior chamber is supposed to be regulated by the balance between secretion, and exhalation through the cornea;[1] and as long as the pupil is open the influence of the exhalation extends to the fluid in the posterior chamber also. But when once the pupil is closed, the fluid in the posterior chamber, although continually increased by fresh secretion, has no longer an outlet, and hence it rapidly increases the tension of the posterior parts of the eyeball. It pushes forward the peripheral or non-adherent zone of the iris; and thus affords early evidence of the exclusion, which may be known to exist whenever this peripheral zone is stretched, convex, and prominent, while the central or pupillary zone is comparatively flattened or receding. Under such circumstances all the tissues of the eye, probably already damaged by repeated inflammation, undergo speedy atrophy. The iris tissue wastes, the vitreous body becomes fluid, the lens becomes opaque and often calcareous,

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[1] [Leber's elaborate researches have shown that exhalation of aqueous humor through the cornea does not take place to any important extent during life, and that the principal channel for the removal of the aqueous humor is probably through the veins of the *circulus venosus* and of the iris. See Leber, *Archiv für Ophthalmologie*, xix, 11, pp 87–185.]

and the retina perishes in the common ruin. There can be no more hopelessly spoiled organ than an eye in which recurrent iritis has been suffered to run its course unchecked, and to produce its ordinary consequences

It is, therefore, a matter of serious importance, in dealing with a first attack of iritis, to prevent the formation of adhesions; and it should never be forgotten that this can be done, with a very near approach to certainty, by the early and efficient use of atropine. When, from any cause, the atropine has not been efficiently used in time, and the inflammation subsides leaving an adhesion behind, such a condition must not be accepted as recovery. In the first place, every endeavor should be made, after the subsidence of the inflammation, to detach the adhesion, or if it cannot be detached to stretch it, by the continued use of atropine. Very considerable adhesions will sometimes yield if the pupil is kept fully dilated and if mercury is cautiously administered. When there is no trace of inflammation left, we may sometimes use calabar-bean and atropine alternately; so as to drag the adhesion first one way and then another; but calabar-bean is an irritant, and must be avoided as long as the slightest abnormal vascularity or sensitiveness remains. The adhesions should be closely examined with a magnifier from time to time, and if they alter, or show signs of stretching or giving way, such changes would furnish reasons for perseverance in the treatment. If an adhesion, without being detached, can even be stretched into a linear band, it may afford the iris sufficient freedom of play; but if no change for the better is visible within a month, I have never seen it commence at a later period. After a month has elapsed, therefore, I do not think there is anything to be gained by the continued use either of atropine or of mercury for adhesions which have remained all that time stationary; and it will then be best to leave the case alone, the patient being fully warned of the further risks to which he is exposed. It seems probable that the action of mercury may really soften and break down adhesions by promoting the absorption and removal of the lymph entering into their composition. But the action of atropine can hardly be any other than a mechanical one; the free portions of iris exerting traction upon those which are attached. If this view is correct, it limits the usefulness of atropine to the cases in which the free portions distinctly preponderate over the rest. If two-thirds of the margin of the pupil are attached, the traction of the remaining one-third cannot be of much avail; and hence, in very extensive or large adhesions, the use of atropine alone is scarcely worth trying. Moreover, in these cases, I think there is less danger of a secondary attack than when there is only a small amount of adhesion.[1] In the latter condition, the major part of the iris being free, the movements of the pupil will be as active as in health, and will be perpetually checked. In the former, when most of the iris is bound down, the movements

[1] [This opinion is, we think, questionable.]

are rather prevented altogether than arrested after they have commenced, and the same amount of irritation is seldom produced.

The effect of adhesions in producing secondary iritis may probably depend somewhat upon their precise position with regard to nervous filaments, and somewhat also upon personal peculiarities. As both of these are uncertain elements, and as, in a few cases, secondary iritis does not occur, no operative interference with the adhesions left by a first attack can, generally speaking, be recommended. Perhaps the only exceptions to this rule are furnished by patients who are about to undertake long voyages, or to travel in countries where they might not, in the event of a recurrence of their malady, be within reach of skilled treatment. But after a second attack of iritis has taken place, there is no longer any reasonable prospect of escape from others: and the conditions previously existing become wholly altered. If the disease be suffered to run its course unchecked, it is probable that total and incurable blindness will be produced in the course of a few years; and the only way in which this danger can be obviated is by the detachment of the adhesions, or by the performance of an iridectomy.

Detachment of adhesions may be accomplished in two ways,—either by the operation of Mr. Streatfeild, or by that of Dr. Passavant.

Mr. Streatfeild's operation, to which he has given the name of "corelysis," is performed by making with a cutting needle a puncture through the cornea, about midway between its summit and its margin, at a point opposite the adhesion to be detached. The needle should be withdrawn without loss of aqueous humor.[1] The "corelysis hook," a fine and narrow spatula with a notch on one side, is introduced through the puncture, carried between the lens and the iris, and so manœuvred as to engage the adhesion in its notch, and to break or cut it by traction across the pupil towards the puncture. For my own use I have had Mr. Streatfeild's instrument modified by bending the spatula, so that it may be introduced on the nasal as easily as on the temporal side of the cornea, and also by enlarging the notch sufficiently to allow of its edges being somewhat sharpened, so that it may cut through a band instead of dragging or tearing it. Dr. Passavant's operation consists in detaching the adhesions by forceps traction, in a direction towards the ciliary region instead of away from it. He makes a small incision with an iridectomy knife in the corneo-scleral junction, on the same side as the adhesion, and, so to speak, behind it. He then introduces forceps like common iris forceps, but without sharp teeth, so that they pinch without piercing, seizes a fold of iris just behind the adhesion, and draws it towards the wound, as if he were going to draw it out for an iridectomy. As soon as he sees the adhesion yield, he ceases his traction, suffers

[1] [Some loss of aqueous humor is inevitable, the anterior chamber becomes refilled, however, in the course of a few minutes.]

the forceps to expand, and withdraws them empty. If a portion of iris should prolapse through the wound, it is replaced by gentle rotatory friction through the closed lids, or, if that should fail of effect, by the extremity of a blunt probe. The eye, after either operation, is bandaged and treated in the ordinary manner; and is brought as soon as possible under the full influence of atropine in order to dilate the pupil and to prevent reunion of the adhesions.

I have practiced both these methods very frequently, and my experience of them has induced me to abandon that of Dr. Passavant entirely,[1] and to reserve that of Mr. Streatfeild for the cases in which there is only one adhesion, or two placed near together, and in which there are strong cosmetic reasons for avoiding iridectomy. Upon a pretty girl with blue irides and well-opened eyes, to whom an iridectomy, even at the upper part of the circle, would be a serious blemish, I should perform corelysis; but I think I should hardly do so under any other circumstances. It is a fault common to both operations that they must be repeated nearly as many times as there are adhesions to be dealt with. When two adhesions are near together, they may be torn through by forceps traction from a point between them, or may be included in one sweep of the corelysis hook; but, if they are too far apart for either of these procedures, they will generally require distinct operations, separated by a sufficient interval of time. For every adhesion there must be a point from which the traction ought to be made in order to be most efficacious; and if a second or even a third adhesion can be reached from the original wound, yet the hook or forceps will act at a mechanical disadvantage in detaching it. Moreover, however fully the eye may have been brought under the influence of atropine, the evacuation of the aqueous humor, and the irritation of the iris by instruments, will produce contraction of the pupil, by which the exact position of any remaining adhesions will be concealed; and it is not prudent to make casts with a hook in the mere hope of catching something, or to pinch up the iris here and there without good reason. In such an eye as that shown in Fig. 70, page 275, at least three operations would be required by either method; and these could not be prudently performed with less than a fortnight's interval between each two of them. Three operations and eight weeks of treatment, even without allowance for failures or complications, constitute a prospect of which a patient might well hesitate to avail himself, and which few surgeons could recommend with sufficient persuasiveness to render it attractive.

A still more serious fault, also common to both methods, is that the adhesions, when detached, often reunite whilst the external wound is healing, so that the objects of the operation are entirely

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[1] [Dr. B. Joy Jeffries, of Boston, Mass., who has given Passavant's operation a somewhat extended trial, reports very favorably upon it, both as regards its freedom from danger and the perfection of its results. We have not performed it, for the reason that, with the author, we prefer a small iridectomy in such cases as seem to demand operative interference.]

defeated. Lastly, in more than one case, I have seen opacity of the crystalline lens produced by the traction. If this had only occurred after Mr. Streatfeild's method, I should have suspected that I might unconsciously have injured the capsule with the point of the hook. But I have seen the same result follow the use of the forceps, which were separated from the lens by the iris, and never entered the region of the pupil at all; and I am therefore compelled to believe that the capsule itself may sometimes tear instead of, or together with, the adventitious band. Dr. Passavant's method, moreover, labors under a disadvantage which is all its own; namely, that adhesion is liable to take place between the cicatrix of the wound of entrance and the peripheral part of the iris. Such an adhesion might be both concealed and unsuspected; but it would not be any the less likely to occasion future attacks of inflammation. On the whole, therefore, my experience of detachment is unfavorable; and I cannot at all re-echo the praise which has been bestowed upon each of the methods which I have described. In order to diminish the traction upon the bands, I devised the cutting-hook in lieu of Mr. Streatfeild's blunt one; and by means of the cutting-hook I think a single adhesion may often be safely and certainly divided, with only a small chance that it will reunite. But when the adhesions are multiple the chances of reunion are greatly increased, and the risks of producing new peripheral adhesions, or opacity of the crystalline lens, are so serious that they should by no means be disregarded.

From the foregoing objections, the remaining resource, iridectomy, is wholly free; and it has the additional advantage of being of almost certain efficacy in preventing the recurrence of iritis. Even if it should fail in this, it will at least prevent exclusion of the pupil by any ordinary attacks, inasmuch as a large gap in the peripheral portion of the membrane is hardly ever (if ever) filled up and dragged together by lymph, except when the operation is performed in the course of irido-choroiditis, and fails to arrest it. It matters little what part of the iris is removed, and it is not at all necessary, nor in any way specially advantageous, to remove the adherent portions. The effect seems to be produced by breaking the continuity of the [sphincter pupillæ] muscle; and hence the operation may be localized with reference to two main considerations, vision and appearance. If the natural pupil is obscured by lymph, the artificial one made by the iridectomy should be placed where it will be most useful for visual purposes; that is to say, downwards and inwards, directly inwards, or directly downwards. By choice, under these circumstances, the part excised should not include an adhesion; because this, when detached, is liable to leave a patch of hardened lymph and uveal pigment upon the surface of the capsule, and these residua would themselves interfere with sight. When the natural pupil is clear, and the vision nearly normal, the iridectomy should be made directly upwards, where it will be at least partly and sometimes entirely

concealed by the upper lid; and it is then a matter of absolute indifference whether the part to be removed is adherent or free.

My experience of iridectomy performed after a second attack of iritis, and when this has wholly subsided, as a means of preventing further recurrence, is now large, and it is altogether favorable. I have never seen the operation followed by any kind of ill-consequence, and I have scarcely ever seen it fail of its object. When both eyes have been affected, I have in several instances operated at first only on the worse of the two, with the ordinary result that it soon became the better of the two, and that its increased usefulness and comfort brought the patient back with a request that the other might be similarly treated. In many persons the existence of an adhesion, while the iris is entire, is attended by painful sensations of dragging, and by congestion of the eyes after even moderate use of them, long before recurrent inflammation is produced. These consequences are at once relieved by the iridectomy.

After several attacks of iritis, in some of which the choroid and vitreous have probably to some extent participated, and when the greater part of the pupil is adherent, the performance of iridectomy is the only resource open to the surgeon. Under these circumstances, however, the amount of benefit to be obtained from it must depend upon the actual condition of the organ, and the operation is no longer entirely free from risk. Several years ago, I iridectomized both eyes at once for a woman who had frequently suffered from iritis, and who was the subject of constitutional syphilis. Her pupils were nearly excluded, and her sight was very bad; the state of the two eyes being almost precisely the same. In one of them all went well, considerable permanent improvement of vision was produced, and there has since been no more inflammation. In the other, sloughing of the cornea took place, followed by suppuration and entire destruction of the eyeball. I have lately heard of an instance in which the operation, also in a syphilitic patient, excited very severe inflammation, with effusion of lymph to such an extent that the anterior chamber was almost filled by it. Still, such misadventures are exceptional; and it is generally fair to say to a patient that iridectomy affords the only chance of preserving his remaining sight, and that it is attended by only an infinitesimal danger of hastening its extinction. Under such circumstances it is judicious to operate on one eye at a time, and to begin with that which is least useful. The iris will often be found friable and rotten, and firmly adherent to the capsule of the lens, so that the anterior layer will tear away in shreds, leaving behind a layer of lymph and pigment which may still prevent the passage of light. In order to obtain an opening, in such cases, it is necessary to let the iris forceps expand widely, and to pinch up as large a fold as possible, in the hope that it may cohere, and that some part of it may come away entire, leaving the anterior capsule free.

As all things human may have at least two issues, so even a first attack of iritis does not invariably follow the favorable or partially favorable course which has hitherto been described. If

the malady has been neglected at the outset, or, still more, if it has been maltreated by nitrate of silver drops or in any other manner, or possibly in certain constitutions, it is apt to pass into a chronic state, to spread to the ciliary body and the choroid, and to place the sight in the greatest peril. I have never seen such a course of events when atropine has been properly applied from the beginning; but I am not prepared to say that even then it might not occur. In iritis which implicates the choroid we find generally that the pupil is contracted and entirely resists atropine; that dilated bloodvessels may be seen, if the cornea and aqueous humor retain even a moderate degree of transparency, upon the surface of the iris itself; that the ciliary region is somewhat tender to the touch; that the hyperæmia is more pronounced, both in the conjunctiva and in the sclerotic pericorneal zone, than in simple iritis; that large and tortuous veins may be discovered emerging from the globe at a short distance from the corneal margin, and passing back under the conjunctiva to the equator; and that the impairment of sight is greater than can be explained by the lymph deposits in the pupil, or by the turbidity of the media in front of it. Among these symptoms, the disproportionate impairment of vision is at once the most significant and the most alarming. It may be explained, to a limited degree, by turbidity of the vitreous body, but it depends, when more marked, upon disturbance of the perceptive elements of the retina. The layer of rods and cones is separated from the choroid only by the layer of pigmented pavement epithelium (Fig. 4, page 27), and a very small amount of choroidal effusion would interfere with the function, and even with the nutrition, of the delicate structures upon which sight essentially depends. For this reason it is characteristic of choroidal affections that they impair vision more rapidly and more permanently than those of the retina itself, which often appear to be limited to the comparatively unimportant connective tissue of the fibre layer. The tension of the eyeball in irido-choroiditis is seldom even temporarily increased; and, as the disease progresses, softening soon becomes evident. The ultimate tendency is to destruction of sight by wasting of the eyeball, and by complete separation of the retina from the choroid by effusion of lymph or serum. The effusions which take place in the choroid itself not unfrequently undergo calcareous degeneration, and in course of time they are sometimes converted into true bone, furnished with Haversian canals.

When choroiditis is grafted upon an attack of iritis which has been under observation and skilful management from its commencement, the case is well-nigh hopeless; and the surgeon has to witness the effects of a process against which he is almost powerless to contend. But if, as sometimes happens in hospital practice, we see irido-choroiditis which has not been treated, or which has been maltreated, there may still be a chance, although not a large one, of arresting the morbid process, and of preserving a useful amount of vision. Our resources for this purpose are

much the same as in the more severe forms of iritis, and their employment should be governed by the same principles. Unless there should be some special contraindication, the constitutional effect of mercury should be obtained as rapidly as possible. Pain should be subdued by anodynes. The strength should be supported by well-chosen diet; strict repose and protection from all irritants should be enforced; and any constitutional conditions which may be contributary to the disease should receive their due share of attention.

It being impossible, in such cases, to remove by atropine the occlusion of the pupil, and generally impossible even to modify it, the performance of iridectomy was long ago suggested as a means of attaining the same end; but I believe that this operation, when practiced in the acute stage of the disease, is never of the least benefit. It is generally attended by very free bleeding from the iris, so that the anterior chamber becomes filled by a coagulum, which conceals the iris and pupil, often occasions great irritation, and is only very slowly absorbed. Next, however large a piece of iris may be removed, the resulting gap, as soon as it can be seen for the blood, will be found to have diminished in size; and its margins will gradually be dragged together by lymph until the original occlusion is restored. The benefits sought from iridectomy may, I believe, be better and more certainly attained by frequently repeated paracentesis.[1] If the anterior chamber be tapped and its contents evacuated, in the manner already described, and if the puncture be reopened with a probe sufficiently often to prevent it from healing, there will be no effusion of blood to do mischief, but a constant drain of fluid, which must be supplied from the distended veins of the eye, and which must in some degree diminish their congestion. The little wound is too insignificant to be hurtful, and the advancement of the lens and iris, consequent upon the frequent withdrawal of the aqueous humor, may prevent injurious pressure from being exercised by the fluids behind them. If improvement should take place, it is manifest that an iridectomy will eventually become necessary for the restoration of sight; and it should be performed during the first distinct remission of the inflammatory symptoms, before the lymph which has been effused in the stroma of the iris has had time to become a source of fresh mischief by the traction consequent upon its shrinkage. After the iridectomy, the treatment must be continued on the same general principles as before; and it will frequently be some months before the effused matters are fully absorbed, the media transparent, and such an amount of sight restored as the injury done by the inflammation may permit. It is not uncommon for the lens to be rendered opaque, and to require eventual removal; and, even then, a subsequent iridectomy may be needed; but these phases of the case will be more appropriately discussed in the chapter upon cataract. During the subsidence

[1] [Advocated by Dobrowolski, *Klinische Monatsblätter für Augenheilkunde*, 1868.]

of the disease, and the period of the absorption and removal of morbid products, the most important questions to be considered will usually have reference to the continuance or disuse of mercury, and these can only be determined by watching its action in each individual case, or, sometimes, by tentatively withholding it for short periods of time.

It is manifest that inflammation of the iris and choroid can hardly exist without inflammation of the intervening ciliary body, "cyclitis," as this affection has been somewhat clumsily called. But in some cases the cyclitis is a subordinate, while in others it is a prominent symptom; and in the latter class there is great danger of the occurrence of "sympathetic ophthalmia;" that is to say, of the excitation of an insidious and almost invariably destructive irido-choroiditis in the previously unaffected eye. Such an event is most frequent when the original inflammation was traumatic in its origin, and especially when the ciliary body has itself been injured, and is therefore primarily affected, the iritis and choroiditis being both secondary phenomena. We have, therefore, come to regard sympathetic ophthalmia very much as a result of injury; but it would probably be more accurate to regard it as the result of cyclitis, of which condition injury is probably the most frequent cause. It would be very difficult, indeed impossible, to determine with any certainty whether some cases of double eye disease are sympathetic, depending upon reflected nervous influence; or constitutional, depending upon some diathesis or other general cause. In many forms of keratitis, and very frequently in glaucoma, we see a second eye attacked in the same manner as its fellow, but later in point of time. In the traumatic cases we infer nervous sympathy; first, because the sequence of the phenomena is too constant to be due to any accidental coincidence; secondly, because no diathetic or other like influence can be common to the many dissimilar people who sustain injuries; thirdly, because the timely removal of the eye which has been hurt will prevent the effect from being produced. But I think these same data should rather incline our minds towards the belief that sympathetic affections may be more common than is generally supposed; and I never see an irido-choroiditis in which cyclitis was the primary mischief, or in which it becomes the prominent symptom, without feeling that the safety of the remaining eye is very seriously imperilled, and that the practice habitually followed after injury would be by far the safest to pursue. The ciliary body is richly endowed with nervous filaments; and the most important evidence of its being acutely inflamed is afforded by its becoming very tender to the touch. It is seldom acutely painful when left unmolested; but if the patient winces at slight pressure upon it, either by the finger through the eyelid, or by the direct application of a probe to the conjunctiva, there can seldom be any doubt that it actively participates in the morbid processes which are going on around it, and that its nerves are irritated accordingly. There is much evidence that irritation of a ciliary nerve is the

starting-point of sympathetic disease; and hence this localized tenderness should never be regarded with indifference, especially if it continues after the subsidence of other acute symptoms. Its presence would not call for any special treatment other than the use of morphia; but it would certainly call for special watchfulness. Sympathetic ophthalmia comparatively seldom occurs in the well-to-do classes, among whom it is generally anticipated and prevented; and in hospital patients any stage of premonition has too often passed away before advice is sought. But there is a certain amount of evidence, which was increased by the experience of the Franco-German war, that an outbreak of actual inflammation in the second eye is commonly preceded by a tendency to lacrymation, by slight impairment of sight and of accommodation, and by the phenomenon known as "interruption of vision," which may be defined and explained in the following manner:

In ordinary continuous vision with two eyes, there are many reasons for believing that although they are always acting in concert, yet that they relieve each other by being, so to speak, active or essential, and passive or complementary by turns If both eyes are fixed on a small distant point of light, such as a distinctly visible and tolerably isolated star, this can be kept in view as long as may be wished, or until the muscles are tired of maintaining the necessary direction of the gaze. But if one eye is closed while the star is fixed with the other, the star will in a short time vanish, to be recovered after a while; when, if it is again fixed with the same eye, it will vanish more quickly than before. The explanation seems to be that the retina of the one eye becomes functionally exhausted at the spot on which the image of the star falls, and thus insensitive to the image until restored by a period of rest. When both eyes are employed, each takes up the active seeing in its turn, and so relieves its fellow.

The loss of the star by the single eye is called "interruption of vision," and a similar phenomenon is common to all one-eyed persons who have to gaze fixedly at any single point or small surface. Generally, however, the interruptions chime in with natural intermissions of effort, and are hardly noticed as sources of inconvenience When they become so, when "interruption" noticeably interferes with the business of life, it is said often to be an early and important indication that the eye so affected is sympathetically irritated by the other.

It is manifest that the symptoms above described, which may be summed up under the general heading of functional impairment of the sound eye, can hardly be manifested during the acute stage of irido-choroiditis, when the sound eye is placed in a state of functional rest as an essential condition to similar rest of the diseased one. They come into prominence at a later stage, when a patient with an eye crippled by inflammation, but still partially recovered, is returning to the duties and employments of life. In such a case, especially if the crippled eye is tender to the touch in the ciliary region, I never hesitate to urge its immediate removal,

whether it has originally sustained injury or not. The same advice should be given, I think, in cases in which one eye has been damaged or spoilt even many years previously, and in which functional impairment of the other becomes manifest after a long period of time. I think I have seen instances in which sympathetic irritation has been due to ossification of the choroid in eyes which had long been useless; and I should always think it desirable to remove a seriously damaged eye, even if it still retained some imperfect vision, rather than to run any risk of sympathetic inflammation. When this condition is fairly developed, even partial recovery can scarcely be expected once in a hundred cases. If the damaged eye has been contused or wounded, the necessity for removing it, under such circumstances, is now universally acknowledged; but when it has only suffered from idiopathic irido-choroiditis the authorities speak with a somewhat less certain sound. In cases of injury it is common to perform enucleation at an early period, long before danger from sympathy commences; and I am disposed to think that this would also be the best practice in many cases of inflammation. The patient would in this way be spared a tedious illness, and would be rescued from the danger of a great calamity. If sympathetic ophthalmia is once set up, its treatment will not be different from that of ordinary irido-choroiditis, but it is far less frequently even partially successful. Enucleation of the eye originally diseased or injured is then always practiced; but I have never seen any evidence of benefit from the proceeding.[1] Before the second eye is attacked, the irritation from the first must have worked some change in the nervous centres; and it is probably from the nervous centres that the secondary morbid action proceeds. As long as the second eye is sound, the removal of the first will afford safety; but when once the second is affected the removal of the first is at least of doubtful utility.

The consideration of the peculiarities of traumatic iritis or irido-choroiditis, and the methods of performing enucleation of the eye-ball, may be appropriately deferred to the Chapter on Injuries; and the description of the operation of iridectomy may in like manner be deferred to the Chapter on Glaucoma.

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[1] [Enucleation, even at this stage, has appeared to us to do positive good in several instances; it should certainly be performed even though it prove in most cases unavailing.]

CHAPTER X.

CATARACT.

The word Cataract, like many others in common use, preserves the memory of an erroneous belief which has long since passed away. It was first applied under the impression that the blindness which it denoted was caused by an opaque curtain, which descended like a cataract behind the pupil, and shut out the world from the eye. In time, when the true nature of the affection became better known, opacity of the lens was usually described as "true" cataract; and a great number of other forms of occlusion of the pupil—by lymph, or by opaque capsule—were distinguished as "false" cataracts of various kinds. Of late years, however, this nomenclature has fallen into disuse. The several forms of "false" cataract are now described in accordance with the actual changes present in each case; and the term "cataract"—no longer with the prefix "true"—is only used to denote opacity of the crystalline lens or of its capsule.

In this sense, cataract is an affection which is met with at any time, from infancy to old age; and more frequently at these extremes than at any of the intervening periods. The cataract of infancy may be either congenital or acquired; that of childhood is generally of the variety called "laminar," which is perhaps often congenital, but overlooked during the earlier years of life; and the cataract of senility is either nuclear, or cortical, or both. In addition to these forms, we have also traumatic cataract. If the capsule is in any way pierced or lacerated by an injury, so that the aqueous humor gains access to the substance of the lens itself, that substance becomes turbid or opaque, with a rapidity proportionate to the extent of the injury and to the softness of the lenticular tissue. Such a result is frequently seen after incised or punctured wounds of the eyeball, and it may also be brought about by blows or shocks, without any external solution of continuity.

In the obviously congenital forms of cataract, it is seen soon after birth that the pupil of the eye, instead of having its natural blackness, is of a white or bluish-white color; and dilatation of the pupil discovers that this coloration is uniform. When the child is old enough to "take notice," it is found that he will follow light with readiness and certainty, but that he has no vision of objects. In such a state the lens is disorganized throughout, and is sometimes found to have undergone entire disintegration and softening. It is probable that there are also less advanced and less conspicuous forms of the same condition, which become more developed after birth; for we meet with children four or five years

old in whom the lenses are of a uniformly imperfect transparency, but yet not white enough to attract the notice of superficial observers. In such instances there is perception of objects as well as of light; and the defective vision does not become remarkable until it interferes with the beginnings of education.

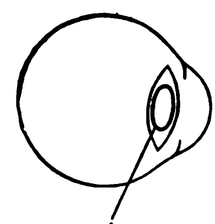
The acquired cataract of infancy is one of the results of neglected purulent ophthalmia, in which central ulceration of the cornea, generally with perforation, has taken place. In these cases, if the ulcer heals firmly, and the turbidity of the cornea disappears, we see in time a small round white spot in the centre of the pupil; and sometimes this spot is a little pyramid, the base of which is adherent to the anterior capsule, while the apex projects forwards through the pupil towards the cornea. A flat white spot is generally very small, seldom larger than the section of a stout pin; but the pyramidal form may often have a base a line or more in diameter. These cataracts are said to be "capsular;" and they are so in the sense that they consist of a deposit which is external to the capsule, and that the lens-substance is not implicated. It is believed, however, that the capsule itself is seldom opaque in such cases, and that the deposit is merely adherent to it. The history of the formation seems to be that, during the course of the purulent ophthalmia, a patch of lymph is left upon the capsular surface; and that upon this lymph some of the saline constituents of the aqueous humor are afterwards thrown down. If there is a small and nearly central perforating ulcer, the lens capsule must come into contact with the perforation as the aqueous humor escapes; and, when the perforation is once more closed, the re-accumulation of fluid will detach the lens from the cicatrix. In such a case, if only a small quantity of lymph is adherent to the capsule, only a small quantity will be carried away; but if a larger quantity is adherent, it is easy to understand how this may be dragged out by traction, and made to assume a pyramidal form with its apex forwards, before it will break from its corneal attachment. Then, in course of time, the lymph serves as a nucleus upon which saline matters may be deposited; and the resulting cataract, whether flat or pyramidal, consists eventually of a substratum of lymph, among which calareous particles are interwoven.[1]

[1] [The microscopic examination, by H. Müller, of central anterior, and pyramidal cataracts, and by Schweigger, of a case of pyramidal cataract, shows that in both the deposit is within the lens capsule, and that the anterior layers of the lens in its central region are more or less implicated. The formation of the central opacity would seem to be due, therefore, to changes in the nutrition of the anterior layers of the lens, dependent upon somewhat prolonged contact of the capsule with, or perhaps upon its adhesion to, the posterior surface of the cornea; in the pyramidal form it would seem that such adhesion has occurred, and has persisted long enough both to effect a dragging forward of the centre of the capsule, and to admit of changes in the anterior laminæ of the lens, sufficient to maintain permanently the conical form of the protuberance. The opacity of the cone and the occurrence of cholesterin or of calcareous salts in its substance, are, therefore, to be explained as results rather of retrogressive changes in the involved portion of the lens, than of deposit of saline matters from the aqueous humor.—See Schweigger, *Handbuch der speciellen Augenheilkunde*, 1st ed., pp. 351–3.]

Either from the small amount of saline matter contained in the aqueous humor, or else from a change in its condition, the deposition shows little or no tendency to increase after the period of infancy has passed, and these forms of cataract, by the time they can be recognized, may be regarded as practically stationary.

In laminar cataract, the opacity is limited to a thin layer of lens tissue which surrounds a transparent nucleus, and is itself surrounded by transparent cortical substance, thus occupying the position of the dark line A in Fig. 72. The opaque patch is always circular when viewed from the front, and is of variable diameter, so that it is surrounded by a narrower or wider belt of transparent lens tissue. The opacity itself is seldom very dense, and is of a bluish-gray color when seen by reflected light. The surrounding belt may be perfectly transparent, or may be more or less dotted or striped by opaque points or lines. The condition is probably, at least in its origin, congenital; but it seldom attracts notice until childhood is somewhat advanced. Mr. Hutchinson has lately shown that it is often associated with a deformity of the teeth, differing from that of inherited syphilis, but equally characteristic in appearance.[1]

FIG. 72.



Unlike the preceding varieties, the cataract of advanced life is neither a malformation nor a result of disease, but is purely a degeneration—an expression of gradual failure of the power to renew the lens fibres in their transparency. In a certain wide sense, it is probably a natural degeneration; that is to say, one which would always occur, as part of the process of decay, if life were sufficiently prolonged. Of the causes that determine its early, or, so to speak, premature occurrence in some persons, we have little knowledge. We know that diabetes must be numbered among these causes; and we know that cataract is often preceded or attended by evidences of disturbance of the ordinary balance of the circulation within the eye. The experiments of Dr. Richardson render it probable that the influence of diabetes is not so much due to the artificial senility which it occasions, as to an increase in the density of the fluid by which the lens is surrounded, and from which it derives its nutriment; and the influence of disturbed circulation, especially in the common form of retarded admission of arterial blood, and retarded escape of venous blood, must be too obvious to need explanation. But a great number of cases of cataract—nay, probably the great majority, cannot be referred to either of these conditions. The change takes place in persons of both sexes, in the robust and in the feeble, in all ranks and conditions, and in no apparent connection with antecedent habits or

[1] [This association of laminar cataract with deformity of the teeth, similar to that frequently observed in rachitis, was pointed out by Horner.—See *Klinische Monatsblätter für Augenheilkunde*, 1865.]

occupations. My own experience leads me to the belief that it is often promoted by an inherited tendency; but I am not acquainted with any conclusive evidence upon this point. Such evidence would, indeed, be hard to obtain, partly from the lapse of time between the incidence of the affection in one generation and in the next, partly from difficulties of diagnosis which have only recently been overcome, and partly from the lax manner in which the word cataract was employed when the parents of the generation now passing away were themselves subjects for the art of the surgeon.

As seen in persons who are past middle-age, the degeneration constituting cataract occurs in two principal forms, which affect respectively the nucleus or the cortex of the lens. Between the portions thus named it is not possible to draw any line of demarcation; for in all periods of life the centre of the lens is somewhat firmer than the exterior, and with advancing years the hardness of the central portion increases, and it assumes at the same time a somewhat yellow tint. When the lens of an aged person is examined, it is found that a certain quantity of the outside of it may be readily rubbed off or washed away, while the rest remains firm and coherent. This latter part is called the nucleus, the former the cortex. In different persons the relative proportion between the two parts differs greatly, the nucleus being sometimes small and the cortex abundant, or the nucleus voluminous and the cortex scanty. When cataract is seated in the nucleus, it is but a continuation or exaggeration of natural changes, a sclerosis or drying and hardening of the fibres, attended by progressive deepening of color and by an increasing obstacle to the passage of light. The centre of the lens becomes yellowish-brown, more or less opaque, and horny, but is surrounded by a cortical layer which is still transparent. When cararact commences in the cortex, it is first seen as an opaque whitish striation, with a tendency towards softening and eventual liquefaction; and it leads ultimately to a state in which a small and hard nucleus is surrounded by a milky fluid derived from the degenerated remains of the external layers.

In all elderly persons, the pupil of the eye loses, in greater or less degree, the characters of blackness and brilliancy which it possessed in youth, and assumes a grayish or greenish appearance. This change is due to two principal factors—first, to the senile coloration of the lens already mentioned, and, secondly [in some cases], to alterations in the fundus oculi (as by atrophy of the optic disk or of the choroid, or by absorption of choroidal pigment), which cause an unusual quantity of light to be returned to the observer. The appearance is not necessarily associated with any impairment of vision, and is often seen in a marked degree in patients who seek advice on account of presbyopia only. It is often seen, also, in those whose sight is failing, and then, if conspicuous, it may present a deceptive resemblance to cataract. Hence, in the writings of surgeons of the pre-ophthalmoscopic era, we find much pains bestowed not only upon an account of the signs of cataract

itself, but also upon the differential diagnosis between cataract and glaucoma; and the marks supposed to indicate these two affections were not uncommonly printed in parallel and contrasted columns, the better to impress them upon the mind of the reader. After all, the differences which were thus enumerated were not entirely trustworthy, and some of them were of a kind to baffle or elude verbal description. Prior to experience, it is scarcely conceivable how difficult to the unaided vision, may be the diagnosis of senile cataract; and how white may be the aspect of the pupil, when the lens is yet perfectly transparent. I was once asked, by an accomplished physician, to go some fifteen or twenty miles to perform cataract extraction, upon a patient whom I had never seen. I expressed a wish that the patient should visit me in the first instance, so that there might be no question about diagnosis on the day of operation; but to this proposal my friend demurred, saying that I might surely rely upon him in so simple a matter. I carried my point, and he brought me an elderly lady who was almost blind, and whose pupils were of a curiously milky aspect. She had simple chronic glaucoma, with some atrophy of the choroid as well as of the optic nerves, so that the light entering her eyes was returned from white surfaces of considerable extent. But I was able to prove to the physician, by the aid of a demonstrating ophthalmoscope, that her lenses were as clear as his own, and to show him the finest details of her optic nerves and retinæ. I have little doubt that the error into which he fell was, at a comparatively recent period, by no means an uncommon one; and that many of the eyes which were operated upon for cataract, even in the first half of the present century, were, in truth, suffering from some very different affection. It is this belief which makes me regard the older statistics of cataract operations as records which do not possess more than a limited and uncertain value.

Nous avons changé tout c la. By the aid of the ophthalmoscope, the bare fact of the presence or absence of cataract, in the former case even in its earliest stages, may be discovered with such readiness and certainty that no doubt can be felt upon the point by any but the most unskilled or careless observer. The examination should be conducted by means of a mirror having only a small perforation, furnished at the back with a magnifying glass of about seven inches focal length, and held at about that distance from the eye of the patient. When the light reflected from such a mirror is thrown upon a normal eye, and when the surgeon looks through the perforation, he sees no details of nerve or vessels, but only the pupil as a circular field of unbroken illumination, more or less yellowish or reddish in tint according to the degree of pigmentation of the fundus. If the crystalline lens is anywhere opaque, the opacity will stop the returning light, and will appear, whatever its own color, as a black object on the illuminated circle. Suppose a room, well lighted, with a window formed of a single sheet of glass, and with a white blind drawn down inside the window. An observer, stationed outside in the dark, would see the whole

aperture of the window equally illuminated. If the window, instead of being formed of a single sheet of glass, were formed of panes, separated by sash bars, these sash bars, although they might be of a white color, would appear to the same observer as black lines crossing the aperture. If no blind were drawn down, and the objects within the room were themselves visible, they might to a great extent obscure or conceal the opacity of the sash bars; and, in the same way, if the surgeon uses the ophthalmoscope in such a manner as to obtain an image of the fundus of the eye, either actual or virtual, the details of this image may obscure or conceal small opacities in the lens. But when no image is obtained, nothing but an illuminated circle, any opacities which may be present, however fine, stand out in bold contrast to the light. In the great majority of senile cases, in which the cataract is primarily cortical, the opacities appear as wedge-shaped striæ, having their bases at the periphery of the lens, and their points directed towards its centre. Their width, their length, their number, and the width of the clear spaces between them, are matters that depend upon the degree of development which the case has attained. When the cataract is primarily nuclear, the opacity will be nearly central in position, and of an approximately circular outline, most dense in the centre, and shading off on every side, but irregularly, towards the margin; and it will present less definite contrasts of light and shadow than those of the cortical striæ. In some instances, the two kinds of degeneration are both in progress, and both nuclear and cortical opacity may be discovered. In the cataract of childhood, the sectors of the lens are sometimes clouded, but separated by intervening lines of transparent hyaline substance; and in laminar cataract the main body of the opacity is perfectly circular in outline, and is of the same density over its whole extent. The transparent belt surrounding it is sometimes perfect, sometimes broken by dark striæ or dots; and, in all varieties, the degree of apparent blackness of the opacities, whatever may be their true color, will depend upon their density, and upon their consequent power of stopping the returning light. When, however, the whole area of the pupil is occupied by a dense opacity, through which only a very small amount of light can enter the eye, it is obvious that the contrasted effects of light and shadow can no longer be produced. The opacity will then have only its front surface illuminated by the ophthalmoscopic mirror, and this surface will be seen in its natural color by the reflected light, precisely as if the patient were standing opposite to a window.

In nearly every case of cataract, at however early a stage, or of whatever kind, the nature of the malady may be discovered, by skilful handling of a suitable ophthalmoscope, without artificial dilatation of the pupil. But dilatation, often necessary to the attainment of certainty by a novice, is sometimes necessary to any one, and is always required before a complete opinion can be given about the peculiarities and prospects of an individual case. If cataract is simply nuclear, and if the pupil is small, so as to be

filled by the opacity, it is not always easy, without some experience, to determine to what cause the defective light penetration may be due; and if it is cortical, and as yet peripheral, the points of the opaque striæ may lie beyond the circle of the pupillary opening, and may thus be concealed by the iris when the observer looks directly into the eye of the patient. Even if the points of opacities do encroach upon the area of the pupil, it must be remembered that only a limited amount of light can enter the eye when the opening is small, that hence only a limited amount can be returned, and that opacities afford less contrast to a dim illumination than to a bright one.

In order, therefore, to conduct the investigation in such a way as not to overlook what is present, the patient must be so placed as to obtain the greatest natural dilatation of the pupil, and to exhibit as much as may be possible of the periphery of the lens. The reverse of these conditions will be obtained when the eye under examination is directed to the centre of the ophthalmoscopic mirror, so as to receive a pencil of light upon the yellow spot, and when the observer looks through a small portion of the centre of the lens only. The conditions are fulfilled when the eye under examination is turned somewhat inwards before the light falls upon it, and when the observer, through a comparatively large pupil, looks obliquely towards the margin of the lens. When this has been done, the eye should be turned successively in different directions, so that other parts towards the margin may also be explored; and, if any doubt then remains, the pupil should be completely dilated before a positive opinion is pronounced.

Figures 73 to 82, all of them accurate portraits from life, are intended to give some idea of the appearances which the ophthalmoscope exhibits in such cases, when used in the manner described. Fig. 73 represents a laminar cataract with transparent periphery, and Fig. 74 a laminar cataract in which the periphery has opaque striation. Fig. 75 represents a fully dilated pupil, with striæ in the cortical substance, creeping from the periphery of the lens towards the centre. Fig. 76 represents the same eye, with natural pupil, but in faulty position. The pupil has contracted in response to light falling directly upon the yellow spot, and the striæ, although they invade the diminished area, are scarcely visible against its dim illumination. Fig. 77 represents the same eye placed obliquely, in such a manner that the pupil does not contract, and the observer is able to look somewhat behind its margin, a position in which the nature of the case becomes clearly manifest Fig. 78 represents an eye in which the striæ are still too much limited to the periphery to be discovered, by any method, until the pupil is fully dilated Fig 79 exhibits the appearance of a case of purely nuclear cataract; and Fig. 80 is a portrait of the eye of a young woman who was operated upon a few months ago in St. George's Hospital, and in whom, without any opacity of the nucleus, both the anterior and the posterior cortex were thickly beset with striæ.

FIG. 73.

Laminar Cataract, with transparent periphery.

FIG. 74.

Laminar Cataract, with opaque striation of periphery.

FIG. 75.

Striæ of Commencing Cortical Cataract (senile).

FIG. 76.

The same Eye, with the pupil undilated and the ga directed to the front.

FIG. 77.

The same Eye, with the pupil undilated and the gaze directed laterally.

FIG. 78.

Striæ of Senile Cortical Cataract in an early sta and limited to the periphery of the lens.

FIG. 79.

Nuclear Cataract (senile).

FIG. 80.

Cataractous Striæ in both anterior and posterior cortex.

Besides the possibility that an opacity actually present in the lens may be overlooked, there is also the possibility that something else may be mistaken for an opacity, or that an opacity in the cornea or in the vitreous body may be erroneously referred to the lens. I have known more than one instance in which the points of eyelashes, intercepting the light, have been at the first glance mistaken for striæ in the cortex. A very faint cloud upon the cornea, such that it is scarcely visible against a background of fair iris, often comes into considerable distinctness by its contrast with ophthalmoscopic illumination. Such a cloud differs from cortical cataract by the absence of striation, and from cataract of any kind by its position nearer to the observer, a point to be readily determined by the range of motion which it displays. The eye, as described at page 102, moves by rotation about a centre; and therefore, in all its movements, a spot upon the cornea will make a larger excursion than one which is seated in the lens. In many cases, the corneal spot will move so far that an uninterrupted view of the fundus may be obtained by the side of it. Opacities in the vitreous, consisting of blood coagula or of flocculi, may deceptively resemble cataract in some instances, of which Fig. 81 furnishes a fair example. The bodies in the vitreous, however, whatever their nature, are usually freely movable, whisking about when the eye is moved quickly, and sinking by gravity when it is at rest; characters which contrast strongly with the stationary and approximately central position of nuclear cataract. There are a few recorded instances of fixed films in the vitreous; but they would be distinguished by their limited excursions as being situated more deeply than in the lens; and any remaining doubt might be cleared up by means of focal illumination.

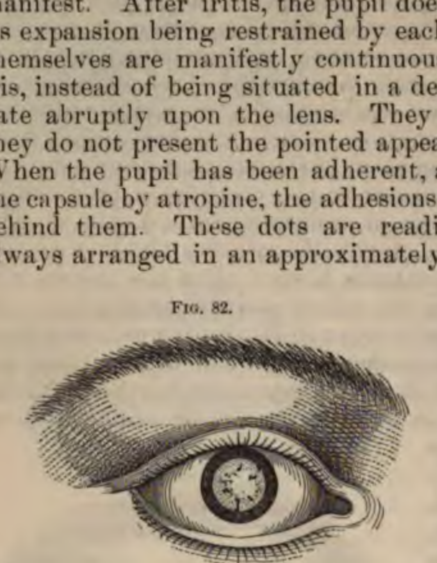
FIG. 81.

Flocculi in the vitreous body, as seen by the aid of the ophthalmoscopic mirror.

The only other conditions likely to be mistaken for cataract when viewed with the ophthalmoscope are those connected with abnormal states of the iris. The band of persistent pupillary membrane, shown in Fig. 3, page 25, might be supposed to be a line of opacity in the cortex; but a careful examination of its surface by direct light would show its attachments and its true character. But the most deceptive appearances are those which are left behind by iritis. In some cases, when the margin of the pupil has been adherent, at two or three points, to the surface of the anterior capsule of the lens, the use of atropine may have stretched these adhesions into little bands, but may have failed to break them. When the pupil is dilated, these bands form opaque lines, which appear black

against ophthalmoscopic illumination, and bear a superficial resemblance to cataractous striæ. They are shown in Fig. 70, page 275, and, if this drawing be compared with Figs. 75, 76, and 77, page 302, the differences between the two conditions will be plainly manifest. After iritis, the pupil does not become quite circular, its expansion being restrained by each of the bands. The bands themselves are manifestly continuous with the structure of the iris, instead of being situated in a deeper plane; and they terminate abruptly upon the lens. They are irregular in shape, and they do not present the pointed appearance of the ordinary striæ. When the pupil has been adherent, and has been detached from the capsule by atropine, the adhesions are apt to leave opaque dots behind them. These dots are readily distinguishable by being always arranged in an approximately circular outline, and, generally speaking, by the presence of irregularities on the parts of the pupillary margin which originally corresponded with them. When seen by direct light, they are of a chocolate-brown color; so that, even apart from the history of the case, no doubt can remain if focal illumination is employed in examining them. Fig. 82 exhibits the appearance of such a circle of opaque dots when seen with the ophthalmoscope; and it may be usefully compared with those which show actual adhesions, and cataractous striæ.

Fig. 82.



Opacities left upon the anterior capsule of the lens by iritic adhesions which have yielded to treatment (viewed by the aid of the ophthalmoscopic mirror).

The cases in which cataract has already arrived at such a degree of development as greatly to diminish vision, or even to produce absolute blindness, have already been said to present to the ophthalmoscope a general or complete, instead of a partial loss of the light usually returned from the fundus. In other words, the light from the mirror fails to penetrate the eye in sufficient quantity to produce by its return a general illumination of the pupillary aperture; and the nature of the case must be determined by other methods of investigation. In cortical cataract an examination by ordinary daylight will usually be sufficient; but in nuclear cataract focal illumination will also be required.

The opaque striæ of the cortical cataract, when seen by direct light, are of a white or yellowish-white color; and, as they increase and coalesce, this color extends itself over the whole surface of the lens, so that the pupil of the eye, speaking very generally, appears to be white instead of black. The change takes place at different periods in different portions of the lens, so that the color at first is seldom uniform, and the cataract presents a more or less flaky or mottled appearance, looking sometimes not unlike a dull opal,

or a piece of spermaceti. Such variegation is an evidence that the cortex still retains some firmness; for, at a later period, when the cortex has become fluid, the color will be uniform or milky, and the appearance of the surface homogeneous. Sometimes, in such cases, particles which are still coherent sink to the bottom of the anterior capsule, and are lost to view behind the iris in the natural state of the pupil, but may be rendered visible by atropine, or by brisk movements of the eyeball. The mobility and subsidence of such particles afford, of course, absolute proof of the fluidity of the cortex; and it is then sometimes possible to ascertain, by focal illumination, that a hard nucleus has also subsided in the same manner.

In the purely nuclear cataract, when the hardened and modified central portions of the lens are still covered by a transparent cortical layer, the color of the pupil is usually of a dark yellowish-brown, and cases are even recorded in which the nuclear cataract is said to have been black. When the ophthalmoscope fails to light up the interior of the eye, and when focal illumination discovers a dark yellow or brown lens, there can seldom be any question about the nature of the case; but the diagnosis of black cataract may be very difficult. I am not sure that I have ever seen one; but a man was admitted into St. George's Hospital, a few years ago, in whose case the question of black cataract arose. He was not more than thirty years of age, of good health, with blue irides and eyes of normal aspect. Both pupils were equally black: and, save for a very faint perception of light, the left eye was blind. He could give no history of the blindness, nor assign any date as that of its commencement. The pupil contracted in unison with that of the other eye; but when the other eye was effectually covered, the reaction to light was very sluggish and imperfect. To the light of the ophthalmoscope the left eye appeared at first to be absolutely impenetrable; and its pupil, examined by focal illumination, was as black as jet. After the fullest possible dilatation by atropine, the ophthalmoscope could be made to show a very fine crescent of light around the upper and inner quadrant of the lens; and the patient was sensible of an unusual brightness. Two hypotheses suggested themselves: the first, that we might have to deal with a veritable black cataract; the second, that there might be some opaque black substance, possibly a pigmented and degenerated blood-clot, lying behind a perfectly transparent lens. I determined to clear up the doubt by extracting the lens, and by having recourse to such other proceedings as circumstances might afterwards dictate; but before the arrival of the day fixed for the operation, the patient received some domestic intelligence of a disquieting character. In consequence of this he left the hospital, and has never returned.

In the eyes of children and young persons, the ordinary forms of cataract are always approximately white by focal illumination, but unless when they are completely milky, are seldom sufficiently opaque to exclude the return of some reddish light from the

fundus. As far as I know, there are only two conditions which could by any possibility be mistaken for cataract in early life; and these are, first, glioma of the retina, and, secondly, a deposit of lymph behind the lens. Some years ago, a child was brought to the Kent County Ophthalmic Hospital (of which I was in temporary charge for Mr. Woolcott), who presented a conspicuous whiteness of one pupil; so much so, indeed, that a gentleman who was present said: "One can see what that case is across the room," meaning that it was cataract. The child had been taken to another hospital a day or two previously, and there the mother had been told that there was cataract, and that, it being then December, a needle operation must be performed in the ensuing spring. On close examination I found that there was no perception of light, that there was great increase of tension, that the iris was pushed forwards into contact with the cornea, and that the almost primrose-colored opaque homogeneous surface seen through the pupil was manifestly behind a clear lens, the brilliant transparency and high refractive power of which were very appreciable. These conditions indicated the presence of a morbid growth within the eye, and enucleation was performed without delay, the tumor proving to be a glioma. More recently, I saw a little girl, nine or ten years of age, whose left cornea had been penetrated by the prong of a fork. There was a good deal of reaction, an opaque white appearance in the pupil, and total loss of sight. The child was a patient at the Royal South London Ophthalmic Hospital, and was shown to me by a gentleman who was acting as deputy for my colleague, Mr. Nettleship, in his absence. In this case, also, I was able to satisfy myself that the very manifest opacity was posterior to the lens, which was transparent and uninjured; and I came to the conclusion that there was some morbid growth, possibly a glioma, in the vitreous chamber. I imagined that the blindness must have been of longer duration than was supposed, that it had escaped observation, and that it had probably been the cause, rather than the consequence, of the injury. I was perplexed by the fact that there was no increase of tension; but attributed this to the recent corneal wound, and to the still tender and yielding character of the cicatrix. I advised the early removal of the eye; and Mr. Nettleship, who returned within a day or two, performed the operation. When a section was made, it was found that the opacity was posterior to the lens, and that it was produced, not by glioma or any other growth, but by a thick layer of lymph which replaced the front portion of the vitreous body, and was in close contact with the whole surface of the posterior capsule. In the examination of presumed complete cataract in young subjects, therefore, it is necessary for the surgeon to be quite sure that the opacity which he sees is really seated in the crystalline lens, and not in some deeper portion of the eyeball.[1]

[1] [An appearance similar to that described in the text is sometimes observed as a result of choroiditis with hyalitis, which may occur spontaneously or as a complication of epidemic cerebro-spinal meningitis; cases of extensive detachment of the

In former days, when ophthalmic surgery was in the hands of only a small number of persons, and when journeying from distant parts of England was difficult, and to the poor impossible, there was no lack of fully developed cataracts; and in remote districts or in country workhouses they were always to be found if looked for. Now, however, they are comparatively rare; and the few examples are chiefly afforded by patients who refuse to submit to any operation for their relief. The effect of the multiplication of eye hospitals, both metropolitan and provincial, and of the establishment of ophthalmic wards in most general hospitals, has been that cataracts, among the poor as well as among the rich, are now nearly always extracted, if not prematurely, at least as soon as is either prudent or desirable. There are, however, two peculiarities, presented by eyes in which cataracts have become mature, which it may be desirable to mention. The first of these is seen in the cortical, the second in the nuclear variety.

In all irides, of whatever color, the pupillary margin is surrounded by a narrow circle which is darkly pigmented, or even black. In the healthy state, this circle is lost in the blackness of the pupil itself, and cannot be seen unless carefully looked for. But when the cortex of the lens has become white, the black circle around the pupil is rendered very conspicuous, and the more so, the lighter is the general tint of the iris. Moreover, when the change in the cortex is complete, even to its most superficial portions, the white opacity seems to fill the pupillary opening, and to be in absolute contact with the black margin, so that the iris casts no shadow upon the lens. If, on the other hand, there is still a superficial layer of cortical substance which remains transparent, the appearance of direct contact between the opacity and the pupillary margin will not be produced, and, with lateral illumination, the iris on the side towards the light will be seen to throw a crescentic shadow on the opacity, of a breadth determined by the thickness of the intervening transparent layer.

In purely nuclear cataract, in which there is nearly always a layer of transparent cortex between the brown or yellowish-brown opaque nucleus and the capsule, the darkness of the opacity renders the black margin of the pupil little, if at all, more conspicuous than in the natural state. But here again the iris, not being in contact with the opacity, will cast a crescentic shadow upon its surface on the side from which the light falls; and here again the width of this shadow, being dependent upon the distance between the iris and the opacity, will serve as a measure of the thickness of the transparent cortex, and therefore, by implication, of the size of the opaque nucleus

When the existence of cataract has been ascertained with certainty, the next step is carefully to study its peculiarities by the aid of both focal and ophthalmoscopic illumination, and to obtain,

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retina, or of the hyaloid membrane, with shrinking of the vitreous, have also been described as closely simulating retinal tumor.]

by a comparison of the results afforded by the two methods of examination, the most exact possible knowledge of all the physical peculiarities of the individual case. The size of the lens, the conditions respectively of its nuclear and cortical portions, and the proportion still existing between its opaque and its transparent parts, are the chief points to which the examination should be directed; and a brief reflection upon the appearances presented will usually be sufficient to leave no doubt with regard to the way in which they should be interpreted.

Next after the existence and the peculiarities of the opacity, the attention of the surgeon should be turned to the presence or absence of any other abnormal condition of the eye. Inquiry should be made as to whether the impairment of sight has been slowly and regularly progressive, or progressive by fits and starts, perhaps with intervals of improvement between them; and, in relation to this matter, the state of tension of the eyeballs, the degree of sensitiveness of the surface of the cornea, and the activity of the pupils, should all be carefully noted. If any part of the lens is still sufficiently transparent, an examination of the fundus should be made with the ophthalmoscope, with especial reference to the vascularity of the substance of the nerve-disk, and to the state of the circulation in the retinal veins and arteries. Lastly, the acuteness of vision should be carefully tested, in order to see whether the degree of impairment of sight is such only as the degree of lenticular opacity is calculated to explain.

The impairment of sight produced by cataract presents several peculiarities. In the first place it is greater, *cœteris paribus*, for distant than for near objects. An elderly person who is not myopic, and who, presbyopia being corrected by spectacles, can read a given type in hand, but who cannot, without spectacles, read a type of proportionate magnitude at ten or twenty feet, is probably suffering from incipient cataract.[1] In the next place, the impairment of sight is at its maximum when the pupil is contracted. This is most conspicuous in nuclear contract, when the opacity is most dense in the centre of the lens, and when dilatation of the pupil uncovers a portion which is comparatively transparent. In such cases, the dilatation will often be productive of marked temporary advantage; and even in purely cortical cases it usually serves to brighten the gathering twilight. It follows as a natural

[1] [A certain degree of myopia coming on late in life is a not very infrequent symptom of incipient cataract. We occasionally meet with elderly persons who, having used convex glasses for years, have found it possible to lay them aside. On questioning them they sometimes acknowledge that distant vision is not quite so good as it once was, but as often, perhaps, they are not aware of it, or else attribute it to failing of visual perception from old age. If we test the vision at a distance we find that it is notably improved by concave glasses, and that with the concave glasses reading is no longer possible. An examination by oblique illumination with dilated pupil generally reveals some cloudiness or faint striæ in the lens, and the case finally develops into cataract. This type of senile myopia appears to be due to a change in form in the lens, which is the precursor of a visible change of structure, and it is in this class of cases only that we have observed a proportionally greater impairment of vision for distant than for near objects.]

consequence, that the cataractous instinctively avoid strong direct illumination. In the early stages of their malady they turn their backs to the lamp or to the window when they wish to do their best in the way of seeing; and in time they come to protect the eyes from light as much as possible, knitting the brows, bending the head, and even putting up the hand as a shade. There is no photophobia, but vision is better in a dim light; the greater size of the pupil being more than a compensation for the lessened general illumination. Cataractous people, therefore, come into a room with a gait which is usually peculiar, and often characteristic, and which differs widely from that of persons in whom from any cause there is impairment of light perception. The former will shade the eyes and bend down the head; the latter will have eyes widely opened and front erect. The remaining characteristics of cataractous blindness are negative. It is not attended by any narrowing of the field of vision; it never destroys the perception of light; and it does not diminish the vividness of the phosphenes, or subjective luminous rings, which are produced by pressure upon the eyeball in a darkened chamber.

It is obviously impossible to define in words the degrees of cataractous opacity in such a way as to connect with each the degree of impairment of sight which should naturally be associated with it; and the surgeon can only be guided by judgment and experience in determining that the impairment, in any given case, is or is not in excess of that which the opacity would explain. But Von Graefe laid down a measure of cataractous blindness in its most extreme degree; and this measure it should never exceed. A person blind from cataract, and from cataract only, when taken into a room lighted by a single candle, should be able to discern the position of the flame at a distance of ten or twelve feet, and to discover in a moment the interposition of an opaque screen. If, whilst he looks fixedly at the first candle, a second one is lighted and moved from place to place within the range of his field of vision, the patient should always, without looking after it, be able to state approximately the position of the second candle also. If these tests (and especially the former) should fail, perfect restoration of sight is not to be expected from any operation; and, if the perception of light is only dim and uncertain, no operation should in any case be recommended by the surgeon, even if it be undertaken in response to the entreaties of the patient.

When the presence of senile cataract in an early stage is first ascertained, the surgeon will often feel some degree of perplexity with regard to the opinion which he should express. In some cases a fear of this affection will already have been excited, and direct questions will be put which it may be impossible to evade. In other cases it may be alike cruel and uncalled for to use a word which will excite a dread of impending blindness. In some aged people the peripheral cortex is beset with opaque striæ, such as those depicted in Fig. 78, page 302, which do not invade the pupillary region for years after their first appearance; and then, although "incipient

cataract" may be a fact, it is a fact which it will seldom be desirable to proclaim. The surgeon will often act wisely to protect his reputation by stating the nature of the case to the friends; but I think he will also act both wisely and kindly if, in many instances, he withholds this knowledge from the patient. When blindness is imminent, and the word cataract is cheering because it implies that the blindness may be cured, then the word may be used without hesitation. But when the blindness is remote, and the time of its incidence is altogether uncertain, there can be no advantage in calling up an unnecessary bugbear, or in saying more than is absolutely required by the conditions actually present. It is of course impossible to adopt any universal rule, and much must depend upon the estimate which the surgeon may form of the character and disposition of the patient. Perhaps the following cases may illustrate some of the different aspects of the question which may be met with in the course of practice.

A gentleman, aged 68, the head of his family and highly placed in the world, and a man of great courage and resolution as well as of cultivated intelligence, consulted me about his sight, thinking very little of the degree of impairment which he noticed. He had only one eye, having lost the other in early life by an accident. He said, "I am like the cats, I see best in the dark." His vision was slightly subnormal, but was raised to the normal standard by a moderate degree of pupillary dilatation. The ophthalmoscope showed the beginning of change in the very centre of the nucleus. There was no opacity, but a little broken refraction of light, an appearance of small cracks like the lines in fluor spar, and the erect ophthalmoscopic image was less clear when seen through the centre of the lens than when seen through any part of the annulus immediately surrounding the centre. I made up my mind to tell this patient the whole truth, viz., that cataract was impending, that the change would most likely be slow in progress, that the eye would probably last as long as he did himself, but that if the failure of vision increased, it would be necessary to have recourse to surgical treatment; in other words, that if he lost his sight it would probably be restored again. With this information he was content; whereas, if I had been less explicit, he would probably have gone from surgeon to surgeon until he found some one to tell him all the facts and probabilities of the case.

A lady of gouty diathesis, and generally feeble health, over sixty years of age, became the subject of glaucoma in the right eye, which was operated upon successfully by iridectomy. Two or three months later I found striæ in the cortical part of both lenses; and as these were not there prior to the operation, I anticipated the rapid development of opacity. The patient could see to read; and, after consultation with her family and her medical attendant, we determined not to say anything about cataract until we were compelled to do so. Before the sight became much more impaired, the lady died of heart disease, and she was thus

saved, by our reticence, from the distress of looking forward to possible blindness.

A gentleman, of highly nervous and sensitive temperament, about sixty, inquired of me whether he might change his spectacles. I found him using lenses of a power too low for his requirements, and, excepting his presbyopia, his vision was absolutely normal. Without assistance he read No. X of Snellen's test-types at ten feet, and with proper glasses he read "brilliant" type fluently. So much of the media as could be seen through the natural pupil was perfectly transparent. When I had finished my examination, he asked me, with some eagerness, whether he had cataract; and, perhaps a little hastily, I replied "Certainly not." He then said that another surgeon had declared that he was the subject of cataract, and would be blind in a year or two; and he added that this opinion was given after a complete dilatation of the pupils with atropine. I made another examination, and in the most extreme degree of obliquity of the eyeball I could just discover the points of a few peripheral striæ. The condition was much like what is shown in Fig. 78, page 302, and might possibly have existed for an indefinite period of time. When the pupillary region is quite clear, and vision is not impaired, the presence of such peripheral striæ is of little moment; and, in a really practical sense, they do not amount to incipient cataract. I believe they exist in many more eyes than is commonly supposed, and that they are not discovered only because there is no reason why they should be looked for. In the particular case in question it is probable that many years will elapse—and even that life may terminate—before these opacities reach a stage in which they will interfere with vision; and to speak about them to the patient could answer no useful purpose, and might not improbably hasten their development. A process of degeneration is dependent upon the state of the nutritive functions; and nothing has a greater tendency to depress these functions than the constant burden of anxiety and suspense.

On these considerations, indeed, rests all that art can accomplish to retard the formation of cataract. Among the many continental quacks who call themselves oculists, and who reap rich harvests from the credulity of English travellers, there was, possibly there still is, one whose *specialité* was the cure of cataract without operation. His practice was to apply atropine to the eyes of his dupes, to speak of the resulting improvement of vision as the first step towards an entire recovery, and then to demand a handsome payment down as a condition antecedent to further treatment of the case.

Putting aside mere rascality, it is probable that there may also have been a certain amount of honest self-deception upon this point. Some years ago, an English practitioner announced that he was able to cure cataract by electricity. Professor Quaglino hoped to arrive at the same end by repeated paracentesis; and, still more recently, the local application of phosphuretted oil has been vaunted

as the true remedy. The electricity and the phosphorus were both, I believe, absolutely useless; and the paracentesis, which was useful within certain limits, was at best but a clumsy and dangerous substitute for iridectomy, the action of which must be presently referred to.

There are, undoubtedly, certain forms of cataract, such as those due to diabetes, and those due to malassimilation in gouty or rheumatic persons whose lives are not wisely governed, in which the physician may do much to improve the general nutrition, and thus, indirectly, to retard the degeneration of the lens, or even to produce some amount of restoration of transparency. If degeneration has progressed to the actual breaking up of the lenticular fibres, to the laying down of calcareous or other deposits, or to the formation of fat-globules, no recovery from these conditions would seem to be possible; but there is no manifest reason why an opacity due to mere sclerosis should not admit of improvement. If this be so, the nuclear are more hopeful than the cortical forms of cataract; although both alike may be hindered in their progress. If peripheral striæ are present in the lenses of a patient of sedentary habits, who consumes more food and more alcohol than he requires, and whose excretory organs are overtasked by waste which they cannot eliminate, there can be no doubt that, under the influence of a suitable diet and regimen, such a person may preserve his eyesight, just as he will preserve his life, longer than if he continued in his unphysiological courses. And therefore, when we see cataract in an early stage, and when we do not find any obvious morbid condition, such as diabetes, the next thing should be to try and discover what there is wrong in the mode of living of the individual, what there is that physiology or common sense would seek to alter in his daily conduct, and why it is, in all probability, that he is no longer repairing the tissues of his crystalline lenses in a proper manner. And here the case falls altogether out of the domain of the mere specialist, and into that of the physician; and the commencing cataract should be regarded not only with reference to its effect upon the function of seeing, but also in a wider and more general way, as an evidence that senile change has made at least one serious inroad upon the system. There is nothing peculiar to the eye in the various considerations hence arising; and it would be altogether beyond the scope and limits of these pages for me to discuss the methods by which the progress of premature decay may be arrested.

There are certain cases, however, in which, either with or without some general perversion of nutrition, there is a local condition which affects prejudicially the vital changes within the eyeball; that local condition being increased intraocular tension. As I shall have to explain more fully when treating of glaucoma, even a small increase of tension, such as may probably be produced by congestion of the choroid, has a tendency to perpetuate and increase itself by its mechanical effect upon the circulation. The principal veins of the eyeball pierce the sclerotic so obliquely that

their calibre is diminished by pressure from within; and then, to the retarded exit of venous blood is added, as a physical necessity of the case, a retarded access of arterial blood. Such changes as these strike at the very root of the nutrition of the organ in which they occur; and the lens, as an extra-vascular tissue, would be likely to be the first part to suffer. Experience shows that there are forms of cataract in which the tension, although not glaucomatous, is distinctly in excess; and in which the impairment of vision is not only a little more than that which the amount of opacity would explain, but in which it varies from time to time, the sight clouding over now and then, and again becoming more clear. In such cases the demand for an early and effectual iridectomy is urgent; and the relief thereby afforded to the ocular circulation, the liberation of the venous and of the arterial flow, will often produce so favorable a change as to postpone indefinitely the further progress of the opacity. In one such instance under my care the cataractous striæ remained absolutely unaltered for four years after the iridectomy, the patient retaining useful vision, and dying without having required any further aid from ophthalmic surgery.

When none of the foregoing conditions exist, when there is neither diabetes nor any other cause of impaired nutrition, when, if any such cause is present, the effect upon the lens is so far advanced that its transparency is past recovery, and when there is no marked increase of tension, the only remaining resource against cataract is the removal of the opacity from the axis of vision. This removal may be accomplished by various methods of operation; and, with reference to these methods, the opaque lenses of the earlier and of the later periods of life are separated from each other by a broad and most important distinction. Prior to middle age, the lens is soft enough to admit of its being broken to pieces by needles, of its being rendered diffluent by the action of the aqueous humor, of its being removed, in this diffluent condition, through a very small aperture, or even of its undergoing absorption within the eye. Subsequently to middle age, its central portion becomes comparatively hard or horny, is incapable of absorption, is liable, if released from its capsule, to act as a foreign substance of the most injurious description, and can only be removed through an aperture commensurate with its magnitude. Even in the most advanced forms of "soft" senile cataract, in which all the cortical portion of the lens is broken down into a milky fluid, this fluid will usually surround a nucleus of great hardness.

In infants, children, and young persons, if a puncture is made through the anterior capsule of the lens with a cataract needle, this puncture will soon appear as an opaque whitish spot, from which a morsel of lens substance will protrude into the aqueous chamber, where it will undergo absorption. The opacity will generally spread through the whole of the lens; and, in many instances, gradual absorption of the whole will follow the single puncture. Sometimes, however, the wound in the capsule will

operation. For the puncture of the capsule a very fine needle should be selected, and should be held with the flat surfaces of its lance point looking forwards and backwards An infant or child should generally be quieted with a few whiffs of ether or chloroform, and an assistant should draw down the lower lid. The operator, standing behind the patient, raises the upper lid with the forefinger of his disengaged hand, placing the pulp of the finger on the tarsal margin, and locking the lid securely against the orbit. The pulp of the middle finger rests on the conjunctiva on the nasal side of the cornea, and, by gentle pressure, restrains the eyeball from rolling inwards. The needle is then placed on the selected point of the cornea, on the temporal side, and about a fourth of the corneal diameter from the margin, so that it can be passed down obliquely to the centre of the lens surface without touching the iris. The needle should be carried through the cornea, and momentarily checked before it is suffered to reach the capsule, the centre of which it should barely incise, making a slit a line in length, but scarcely penetrating into the lens tissue, and being immediately withdrawn. If the needle is well made, the loss of aqueous humor should not exceed two or three drops, and no bandage will be needed. On the following day a small projection of lens matter into the anterior chamber will indicate the rent in the capsule. The pupil must be kept dilated, and the eye examined from time to time. As long as fresh portions of lens substance project, and take the place of those which are successively absorbed, all is going on well; but if this process should cease the operation must be repeated, and on the second occasion the needle may be used rather more freely than on the first, so as to make a larger rent in the capsule, and a deeper opening into the lens tissue. The same course of events may then recur, and the needle must be used as often as may be necessary, until at last the lens substance has all disappeared, leaving a pupil which is either clear, or obstructed only by films or shreds of capsule.

When a more speedy result is to be attained by the removal of the softened lens, the operator will generally find it desirable to separate the lids by a speculum, and to use two needles, one introduced on the temporal, the other on the nasal side of the cornea. With these, the lens should be literally cut to pieces by close parallel strokes, passing through it from margin to margin, each needle reaching most conveniently the half of the lens which is farthest from its entrance wound. In managing this cutting up, or "discission" of the lens, some care and knack are necessary. If the needles are used too sparingly, the lens fragments may be too large to undergo very speedy softening, or to pass through the small opening by which they ought to be removed; while, if the needles are used too freely, they may pass through the lens altogether, wound the hyaloid membrane, and bring the vitreous body upon the scene; a complication of affairs which is not always harmless, and certainly never desirable. When the needles are withdrawn, a pad and bandage may be applied for twenty-four hours, at the

end of which time the punctures should have healed, and the anterior chamber, if the discission has been complete, should be occupied by a soft whitish substance, resembling a flocculent precipitate. There should be very little conjunctival hyperæmia, and no zone of sclerotic congestion around the cornea. The pupil should be kept fully dilated, and the patient should be seen at least daily. Generally speaking, the evacuation of the lens matter may be deferred for three or four days, or even for a week, in order that it may be thoroughly softened by the aqueous humor; but, on the slightest appearance of inflammatory reaction, the little operation should be performed immediately. The object in view may be accomplished either with the slender spoon of a curette (Fig. 83), or by means of a suction tube.

FIG. 83.

In order to use the curette, an incision should be made with a lance knife on the outer side of the cornea, parallel to its margin, and about half-way between margin and centre. This incision should seldom exceed two lines in length, and the blade should be withdrawn without much loss of aqueous humor. The spoon of the curette may then be introduced with its concavity forwards, and turned, when its point reaches the pupil, so as to bring the concavity upwards, and to separate the lips of the wound, thus forming an open channel through which the softened lens matter may be forced out by the elasticity of the ocular tunics, aided by the action of the external muscles. The exit may be assisted, if necessary, by slight movements of the spoon within the chamber, or by slight pressure with the fixation forceps, but both these proceedings must be had recourse to sparingly and with precaution. The latter may easily rupture the hyaloid membrane and permit the escape of vitreous; the former may easily irritate or injure the iris. For these reasons, when any fragment of broken lens does not escape, either because it is held between the iris and cornea or for any other reason, it is usually better to leave it to undergo absorption than to make repeated efforts for its removal. When all has escaped that will come, the eyelids should be closed and bandaged; and, after twenty-four hours have elapsed, atropine should be applied daily, as long as any turbid matter, capable of being absorbed, remains in the pupil or in the anterior chamber. If pain, swelling of the lid, or any other symptom of inflammatory reaction, should appear on the second or third day, a leech or leeches should immediately be applied over the temporal region, close to the outer margin of the orbit, and should be followed by cold compresses, and, if necessary, by the use of morphia, on the principles already laid down in discussing the treatment of iritis. If these measures fail to arrest the mischief a large iridectomy should usually be performed without delay, and any remain-

ing fragments of lens matter should, as far as possible, be removed during the operation.

The evacuation of the softened lens matter by suction is a proceeding of great antiquity, supposed to have originated in Persia, which was reintroduced, some few years ago, by Mr. T. Pridgin Teale, of Leeds. It is performed by means of a small slightly curved tubular curette, which is semicircular in section, smooth and rounded at its free extremity, and provided with a small round or oval opening near this extremity, in its flat or concave surface. The curette has been attached to more than one form of exhausting syringe; but its action is beyond measure most effective and most delicate when it is fixed to a glass tube which serves as a handle, and which is connected by an india-rubber tube with a glass mouthpiece, thus forming the instrument shown in Fig. 84. The curette itself may be of various sizes, and its orifice may be sufficiently large to remove quite considerable fragments. It should be introduced through a corneal opening only just large enough for its passage, and in the same position as that required for the scoop, or even somewhat nearer the margin. The flat or perforated side should be turned towards the inner surface of the cornea, and the extremity should be made to dip down a little into the lenticular space, so that the perforation may not be closed by the cornea coming in contact with it; an event which may also be guarded against by having a transverse notch across this perforation. When thus placed, gentle mouth suction will draw all the lens matter through the aperture, and into the glass tube; and any stray fragment may be followed until the aperture is below it, when it must needs fall into the stream. If there is suspicion that the tube is anywhere obstructed, it may be withdrawn from the eye, blown clear, and reintroduced; and throughout the operation the course of the fragments should be carefully watched, and the suction regulated with a nicety which no mechanical substitute for the mouth can imitate.

FIG. 84.

The advantages of this method over the preceding one are the gentleness with which it may be said to entice away the whole of the lens substance, the power it gives of readily removing even large fragments, and the diminished risk of bruising the iris or of rupturing the hyaloid membrane. The after treatment is the same as when the scoop has been employed.

In both operations, the object of making the entrance wound at some distance from the margin of the cornea is twofold. In this situation it facilitates the passage of the curette into the lenticular space, and it is attended with little liability to prolapse of the iris. If a portion of iris should follow the instrument on its withdrawal, the prolapse may be reduced by gentle friction through the closed lids, and is not liable to recur. If a bead of vitreous should escape, it may be cut off with scissors, close to the cornea, before the compressive bandage is applied.

A very few cases are met with, both in infants and young persons, in which the whole of the lens has undergone liquefaction, so that the cataract consists only of milky fluid contained within a capsule. As soon as the capsule is punctured, the fluid escapes, and mingles with the aqueous humor, concealing the iris and pupil from view.[1] The presence of this fluid in the anterior chamber is not only apt to produce severe local irritation, but also sickness; and it should be evacuated without delay. As soon as the puncture of the capsule reveals entire fluidity of the cataract, the operator should withdraw the needle, make an incision as for paracentesis of the chamber, and suffer the whole of the mingled lens matter and aqueous humor to escape.

Excepting in the cases last mentioned, and in early infancy, when, from the activity of absorption, the comparative unimportance of loss of time, and the small size of the parts, I think simple solution preferable, I have now for some years treated all cataracts in patients under thirty by discission and suction. If I had been writing little more than a year ago, I should have described the method as being practically free from danger; for at that time I had never seen it followed by any result except a good recovery. But in May, 1874, I admitted into St. George's Hospital a healthy boy, with laminar cataract of both eyes; and performed discission of one lens, followed, after a few days, by suction in the ordinary manner. Acute iritis supervened, and led to the formation of pus in the anterior chamber. The hospital was on the eve of closing for three months for alterations and repairs; and Mr. Power kindly received the boy into his ward at St. Bartholomew's Hospital. It is unnecessary to say that nothing was there omitted which could conduce to his recovery; but notwithstanding skill and care, the suppuration extended, and the eye, totally disorganized, was removed by Mr. Power in order to terminate the patient's sufferings. In October, 1874, I received into

[1] [We have seen the milky fluid dissolve and disappear in the aqueous humor as soon as it escaped from the punctured capsule.]

St. George's the patient whose right eye is shown in Fig. 74, page 302, as affording a typical example of laminar cararact extending into the periphery of the lens. The left eye was operated upon by discission and suction with entire success. Discission was then performed on the right eye also, and was followed by suction—the latter operation on a Friday. I saw the patient at 2 P.M on Saturday—when all was well. On Monday I was summoned to the hospital, to find her eye inflamed and intensely painful, and the anterior chamber half full of pus. She said that the pain commenced shortly after my visit on Saturday, and had since gone on increasing in intensity. I immediately made a large iridectomy downwards, evacuated all the pus, applied an evaporating lotion to the closed lids, and ordered a small dose of morphia every hour until pain was relieved. The next morning I found her comfortable, and the inflammation gradually subsided. The opening in the iris became closed by lymph; but a second iridectomy, performed early in December, has restored a useful degree of vision, which will probably be still further improved. While this patient was in the hospital, I performed discission and suction upon the right eye of a boy three years old; and in his case there was troublesome plastic iritis, which required an iridectomy, and left a much-damaged organ. My recent experience, therefore, would lead me to speak of suction with somewhat diminished confidence: but I still think it is the best method of removing cataracts in the cases for which it is suited. It is not, as I once believed, almost without risk; but I still think that the risks which it entails are less than those which attend upon other methods; and I am not at all satisfied that the unfavorable results, in the cases above mentioned, may not have been due to causes not essentially connected with the procedure. It is difficult to clean the suction curette thoroughly, and it cannot be put into hot water without dissolving the cement which unites the silver portion of its tube to the glass. It occurred to me that the ordinary washing with cold water after use might have left some particles of organic matter in the channel, and that these, accidentally introduced into other eyes at subsequent periods, might have excited the inflammation described. I have since taken the precaution of soaking the curette for some hours in diluted Condy's fluid, and of then washing it well in pure water immediately before an operation; and my cases subsequent to the adoption of this precaution have done well. Mr. Teale informs me that his own experience of suction is highly favorable; but I have heard less satisfactory reports from other sources.

In the cataracts of early life, when they invade the whole of the lens, an operation for their removal should generally be performed as soon as the nature of the case is discovered. In manifestly congenital cataract, solution should be undertaken, as a rule, during the third month, so that absorption may have made good progress prior to the commencement of the troubles of dentition. The chief reason for operating early has been mentioned in con-

nection with the corneal opacities sometimes left by purulent ophthalmia; namely, that a want of perception of objects during infancy, deprives the ocular muscles of their physiological stimulus to action, and leads to a permanent impairment of their tone, which manifests itself in the constant oscillation of the eyeballs known as nystagmus. The cataracts which escape notice until childhood, or until the commencement of school-life (and which too often escape notice until the child has been repeatedly punished for a "stupidity" which is really blindness) are, I believe, generally congenital, but the lenses are less white, less conspicuous, and not sufficiently opaque to produce nystagmus. Still, if the whole surface of the lens is implicated, the opacity will almost certainly increase, and will certainly not diminish. An operation will be necessary eventually, and nothing can be gained by delay. Even if the patient can see his way about, he cannot see the world; and he loses every year the valuable educational influence which the sight of the world exerts.

In laminar cataract the case is somewhat different. The opaque circle in the lens is surrounded by a transparent border, and it often happens that through this border good vision may be obtained. It may be laid down as a general rule that when the border is absolutely clear, as in Fig 73, page 302, it will be likely to remain so; but that when it is invaded by opaque dots or striæ, as in Fig. 74, it will become wholly opaque in time. When such invasion of the periphery exists, the lens will almost certainly require to be removed eventually; and therefore, if the defect of vision is considerable in degree, it may as well be removed soon as late. But where the periphery is clear the removal of the lens may often be altogether avoided, either by the use of atropine or by an artificial pupil. It is obvious that when there is no lens it must be optically replaced by some artificial substitute before clear vision can be obtained; and also, as the artificial lens can have no variation of adjustment, that different powers will be necessary for different distances. Every person from whose eyes cataracts have been removed requires at least two pairs of spectacles of high power; and this requirement is obviated when removal of the lens can be dispensed with. If, therefore, the border around a laminar cataract is perfectly clear, the first question that will arise is whether this clear border can be rendered available for visual purposes; and the answer will greatly depend upon the breadth of the border. If the opacity is of small diameter, and the border correspondingly broad, it may be brought into use by moderate dilatation of the pupil, such as will not uncover the extreme margin of the lens, and such as may be produced by a weak solution of atropine, which will not entirely paralyze the accommodation. Many persons with small laminar cataracts, and who are not hypermetropic, enjoy excellent sight by the regular use of atropine, although they are generally called upon, for reading or other near work, to reinforce their accommodation by ordinary spectacles. If the laminar opacity is of large diameter,

and the border correspondingly narrow, the latter can only be uncovered by complete dilatation of the pupil. This involves complete paralysis of accommodation; or, if the eye be at all hypermetropic, as great an occasion for two pairs of spectacles as if the lens were absent; and moreover, the aberration produced at the extreme margin of the lens is generally more or less disturbing to vision. Notwithstanding these inconveniences, the rule of practice is to leave the cataract alone, whenever, by dilatation of the pupil, with or without the aid of glasses, sufficient sight for the requirements of the patient can be obtained.

In some few instances, atropine produces local irritation, which necessitates the abandonment of its use; and it must always be a misfortune to be permanently dependent for sight upon a drug which is a dangerous poison, which is costly, and which can only be obtained in settled countries and populous places. Hence it has long been customary, in some cases of laminar cataract, to make an artificial pupil in front of the clear border of the lens; and this has been done in the various ways already mentioned in discussing corneal opacities —namely, by iridodesis, by radial division of the iris, and by iridectomy. Mr. Critchett claimed for iridodesis, in these cases, that it not only preserved the contractile function of the pupil, and established an opening in the precise place where it was wanted, but that it was also useful by dragging the iris over the opacity, and thus covering it up, so that the imperfect sight obtained through it might not be disturbing. There is no difference in principle, in making an artificial pupil, depending upon whether the opacity which calls for the operation is in the cornea or in the lens; and I need not repeat the reasons which I have already assigned for preferring iridectomy to the alternative methods of procedure. The piece of iris excised should be as narrow as possible; and, unless the cataract is of large diameter, all that is required is to cut a mere notch out of the pupillary margin, leaving the peripheral part of the iris untouched, and the extreme border of the lens still covered by its natural screen. If the artificial pupil does not afford the results which were hoped for, and if optical aids fail, the absorption or removal of the lens is a course still open to the surgeon; but before this course is recommended the case must be most carefully considered in all its aspects, and especially with reference to the amount of sight actually enjoyed and to the risks of an operation. Under no conceivable circumstances should both eyes be operated upon at once, or the second until the first has entirely recovered; and the circumstances would be very unusual which would justify an operation upon the second eye, if the result of that performed upon the first had been unfavorable. It is not possible to state the risks attendant upon the removal of congenital or laminar cataract with any approach to precision. In the great majority of cases, in which the cataract may be regarded as an accidental fault in an eye otherwise healthy, the risks are probably so small as to be almost non-existent; but if the cataract is itself an expression of

imperfect nutrition or defective reparative power, then inflammation may be readily excited and may also be likely to assume a destructive character. If the eyes are obviously malformed, even by being in a high degree hypermetropic, if the globes are small, if the pupils resist atropine, if the lenses are not concentric with the corneæ (congenitally dislocated), if there should be coloboma of the iris, or remains of pupillary membrane, or other evidences of arrested development, if the defect of sight should be greater in either eye than the state of its lens will satisfactorily explain, or if there should be strabismus, in all these conditions I should regard the prospects of benefit from an operation as being small, and its dangers as being large in a commensurate degree. Under such circumstances the surgeon can only state the case frankly for the decision of the patient, and will usually act most wisely if he leaves that decision to be based upon the evidence alone.

When a cataract has been treated either by solution, or by discission and suction, the best condition which can be attained is to leave the posterior capsule of the lens transparent, uninjured, and adherent to the hyaloid membrane; while the anterior capsule has retracted from the central wound inflicted upon it, and forms a white ring, larger than the natural pupil, and concealed by the iris until the pupil is dilated. This white ring is opaque; and if the operation has been so managed that there are two or more openings in the anterior capsule, or one opening which is either insufficient in size or not centrally situated, the area of the pupil, when the lens is all gone, may yet be obstructed by opaque capsular bands. It is said that the anterior capsule never becomes opaque in its actual tissue, and that the bands can be unfolded under water into transparent films; but this consideration has no practical bearing on their effects upon sight. Moreover, if the process of removing the lens has been attended by the smallest degree of iritis, the bands of capsule are apt to be reinforced and held together by effused lymph; and the pupil may be so much blocked up that sight may be scarcely improved. In some cases too, after the most successful operations, the posterior capsule will become cloudy. I have seen this happen quite suddenly, many months after normal vision had been restored. From these various conditions we are liable to find the pupil occupied by membrane, which is sometimes continuous, sometimes cribriform, sometimes altogether irregular in shape, sometimes merely filmy, sometimes tough and densely opaque; but always in direct connection, through the suspensory ligament of the lens, with the circle of the ciliary processes. The exact character of this membrane may be ascertained, and its peculiarities discovered, by the combined use of focal and ophthalmoscopic illumination, the pupil being first fully dilated. In some instances the bands will be adherent in places to the pupillary margin itself.

The treatment of these residual opacities has occasioned great perplexity. It seemed an obvious resource to make an incision through the cornea, to seize the film with forceps, and to extract

it; but this simple plan has been so frequently followed by destructive cyclitis, or by suppuration of the eyeball, that it has been generally abandoned. It was at one time the practice to try to drill holes through the membrane with a needle, or to tear the bands in two, or to push them down into the vitreous; but all these things were more easily talked about than accomplished. The membranes are generally elastic. The needles passed through them, leaving openings too small to be useful. Bands were found to stretch or yield instead of breaking; and, when released from pressure, they returned to their former position. At length Mr. Bowman devised the admirable expedient of using two needles at once, one introduced on each side of the cornea; and by this plan almost any band may be torn, and a central opening may be made in almost any membrane. The two needles may be made to pass through the same perforation, and then to tear it into a rent, without traction on the ciliary body, by separating their points; or they may be entangled in a band, and made to break it by a similar manœuvre.

There will yet remain a few instances in which capsular films cannot be dealt with in this manner, and in which their removal from the eye is desirable. These are the cases in which the films are very dense, tough, and extensive, or in which they are adherent to a large part of the pupillary margin; and they occur more frequently when the absorption of the lens has been due to disease than when it has been brought about by surgical means. For such cases I have contrived a method of extraction with which I have had reason to be well satisfied.

The pupil being first dilated as completely as possible, the patient fully under the influence of an anæsthetic, and the eyelids separated by a speculum, I pass two needles at once into the anterior chamber, one on the nasal, and one on the temporal side of the cornea. The needle introduced on the nasal side has the ordinary cylindrical shaft and lance-head, the cutting sides of the latter being a little longer than usual, and the shaft having been carefully tested to see that it will both fill the wound and move freely within it. The needle introduced on the temporal side is flat, two-edged, and as small as it can be made consistently with these characters. With the point of the first needle I sever or tear, as completely as possible, the attachments of the film on the temporal side; and with the point of the second needle I do the same to the attachments on the nasal side. The temporal or flat needle is then withdrawn, and is made in its exit to enlarge its own wound, by a lateral cut, sufficiently to admit a pair of canula forceps. These being introduced, and permitted to expand in the pupillary space, the film is guided between their blades by the point of the remaining needle, and gentle and carefully watched traction is made. If the film has any remaining attachment, if it drags anywhere, the needle point is applied to this attachment, so as to sever it; and the film is not removed from the eye until all remaining adhesions have been cut in this manner. I have performed the operation

thus described in several cases, and have never seen it followed by any worse effect than some very transient tenderness. It might, of course, be productive of cyclitis in a subject especially predisposed to inflammation; but this danger is a small one, when set against the benefits of a free iris and an unobstructed pupil.

[For removing secondary cataracts or other membraniform obstructions from the pupil, the following operation, devised by Dr. C. R. Agnew, of New York, is one of the best. "The pupil having been dilated by atropine, and the spring speculum inserted, the operator passes a stop-needle (see B, Fig. 43, page 153) through the cornea, about one line from its nasal border, and transfixes the membraniform obstruction. Then, while holding this steady, he makes an opening in the cornea, about half a line from the temporal border, with a Beer's knife, a lance-shaped knife, or a broad needle. Through this opening a sharp hook is introduced and its point entered in the opening made in the membrane by the stop-needle. If possible, the hook is now to be rotated and the membrane rolled up around it and brought out of the anterior chamber. If it cannot be drawn out it should be torn. After the operation a solution of atropine (two grains to the ounce) should be used again. The patient should be kept two or three days in bed in a darkened chamber, and then gradually accustomed to the light. The great advantage of the stop-needle is that it prevents traction on the iris."—*Stellwag on the Eye*, 1st American edition (1868), p. 544.]

In persons who have reached or passed the middle period of life (and the indefiniteness of this phrase is due to the fact that age cannot be measured by years), the nucleus of the lens has usually attained such hardness that it can neither be broken up by needles, nor rendered diffluent by the action of the aqueous humor. In the same persons, too, the iris is much less tolerant of traumatic cataract than in the young, is less amenable to the action of atropine, and much more prone to severe and intractable inflammation. For such persons, therefore, the operation of solution or of discission is unsuited; and, putting aside the old method of couching as one which is completely and deservedly abandoned, it may be said that the only prospect of restoring sight in senile cataract rests upon the performance of extraction. The object of every method of extraction is to remove the lens, both nucleus and cortex, entirely from the eye by one procedure; since any part which remains will not only be an obstacle to vision, but also a probable exciting cause of dangerous inflammation. The cortex, in its natural state, is not only transparent, but also somewhat viscid; it clings to the interior of the capsule, and, by reason of its transparency, eludes observation. After a short exposure to the aqueous humor it swells and becomes opaque, precisely as in the forms of cataract which have already been considered; and many an inexperienced operator, after extracting an opaque nucleus and leaving an apparently clear pupil, has been painfully surprised to find the pupil occupied on the following day by a mass of white flocculent

material, which in the course of a few more hours set up iritis, and if it did not destroy, at least imperilled the eye, and rendered necessary a second operation for the division or removal of false membrane. In nuclear cataract, this particular risk is at its minimum when the superficial layer of transparent cortex is at its thinnest, and when even this has so far participated in the sclerosis as to be disposed to form part of, and to adhere to the nucleus, rather than to the capsule. In cortical cataract, the risk is at its minimum when the degeneration has not only spread over the whole surface of the lens, but has also involved the most superficial layers. A cortical cataract, therefore, is said to be mature, or "ripe," when the light of the mirror no longer penetrates its substance, and when the iris, being, save for the intervening capsule, in contact with the opacity, casts no shadow upon its surface. A nuclear cataract is mature under the same conditions as regards light penetration; and when the shadow of the iris is extremely narrow. Both varieties are then in the best state, surgically speaking, for extraction; and both, if left longer, may present less favorable conditions. The cortex, when it passes into a liquid state, sometimes becomes possessed of irritating qualities; and when hard it sometimes becomes the seat of calcareous or other deposits, which may inflict mechanical injury during their exit from the eye.

In former times, when the flap operation for extraction was the only one practiced, the percentage of lost eyes was so considerable that it became almost a rule with surgeons not to operate as long as any vision of objects was left, as long, that is to say, as an unfavorable result would for the time alter the state of the patient for the worse. Hence has grown up a tradition that cataracts should not be touched until they are fully ripe; and the tradition, like many others, has kept its hold upon the public, and to a less extent even upon the profession, after the conditions in which it had its orgin have been changed. It is still true, that when we operate upon fully mature cataracts we have a greater prospect of immediate and complete success than when we operate upon others; but it is also true, that by modern methods we now operate upon immature cataracts with a greater prospect of success than the surgeons of twenty years ago had in dealing with those which were mature. Moreover, the difference of risk in the two cases is no longer what it was, and may be regarded as being altogether subordinate to considerations of a different kind, which arise out of the social state or the moral character of the patient.

Other things being equal, we must clearly recognize that an operation upon an immature cataract involves an additional risk of failure; but I am not aware of any statistics which enable us to set forth this additional risk in figures, or to reduce it to a percentage. I have already expressed some doubt with regard to the value of existing numerical records; and this particular point could only be satisfactorily solved by the very large experience of some single operator. The different amount of care bestowed by different surgeons upon certain details of procedure is alone suffi-

cient to render a comparison of their results misleading rather than instructive.

The success of any operation for the extraction of cataract, supposing it to have been perfectly well planned and well executed, will depend chiefly upon the rapid and uninterrupted completion of the healing process; and this, in its turn, will obviously depend, first, upon the general nutrition and reparative power of the patient; next, upon the local nutrition and reparative power of the parts implicated in the operation; and lastly upon the absence of accidental causes of disturbance. Every surgeon knows that there are some persons in whom any wound heals tardily and badly, in whom all the tissues are deficient in plasticity, and in whom there is a tendency to the formation of pus. Every ophthalmic surgeon knows, also, that there are persons in whom the reparative power of the eye is exceptionally feeble. The cornea, when not manifestly unhealthy, is so perfectly transparent that its thickness and density cannot be estimated. But there are some corneæ which possess considerable thickness, and which are so firm that they not only offer an appreciable resistance to the keenest knife, but, as ladies say of silks, they will stand by themselves, and will preserve much of their natural curvature when the aqueous humor has been evacuated, and the lens removed. There are others which the knife can scarcely be felt to penetrate, and which collapse into thin and wrinkled membranes as soon as the support of the aqueous humor is withrawn from them. In corneæ of the first class, the edges of an incised wound remain in apposition, and are often closed by primary union in a few hours; while in those of the second class there is not only a mechanical tendency in the edges of a wound to fall asunder, but there is also a liability to complete necrosis from the shock of the injury. I am disposed to think that the differences thus referred to are at least as frequently due to differences of local innervation as to systemic conditions; for, although feebleness of the cornea must be looked for as part of the general state of feeble and emaciated persons, and especially in connection with a relaxed and inelastic state of the skin, yet it is also met with in cases in which the skin is well nourished, and in which the general health appears to be perfectly satisfactory. Of this there can be no better illustration than the central atrophy which is the immediate cause of conical cornea; but when feeble cornea is associated with cataract, the defect of nutrition is usually, I think, common to all the textures of the eye, and the cataract itself is but one of the ways in which it finds expression. By such conditions the most confident hope of a successful issue may sometimes be disappointed; and experience has taught me the necessity of giving a very guarded prognosis in all cases in which cortical cataract becomes mature at a comparatively early period of life. In such there is premature senility of the eye, if not of the body generally; and the most successful manipulation is liable to be followed by complete failure of the healing process.

Putting aside these instances, as being in some sense exceptional,

there remains the general truth that the prospect of restoration of sight is greatly dependent upon the state of the general bodily nutrition; more dependent upon this indeed, at least in my opinion, than upon the degree of maturity of the cataract which it is proposed to remove. It hence becomes necessary to consider whether the general nutrition is likely to suffer by the postponement of an operation until the cataract is mature. If both eyes are affected, and if the patient is dependent upon them for his means of living, a time must come when even the better eye of the two will no longer enable him to obtain his wonted comforts; and after this period has been reached any further delay may involve physical privations likely to injure the bodily health. If a laboring man, on account of failing sight, cannot live in the way to which he has been accustomed, I think the risk of an immediate operation on an immature cataract is less, generally speaking, than the risk of an operation deferred over an unknown time of privation and despondency until the cataract is mature; or in other words, that the advantages of maturity might be more than counterbalanced by the disadvantages of a debility artificially induced by anxiety and privation. With hospital patients, therefore, and with all others under similar conditions, I advise an operation upon the worse eye as soon as the sight of the better one is so much impaired as seriously to limit the means of living. If this operation is successful, the question of an immediate or deferred operation upon the second eye is one which must be decided by the patient with reference to his individual requirements. If the first operation is unsuccessful, and especially if it is unsuccessful by reason either of the risks incidental to immaturity of the cataract, or by reason of want of reparative power in the eye, it is usually prudent to defer the treatment of the second eye until maturity has been attained, or until the patient is so far blind that the loss of the perception of light is the only further loss which he can sustain.

The question of the cessation of earnings does not come under consideration when we have to advise patients who are comfortably circumstanced; but even upon them a very injurious influence may be exercised by mental emotion. This, the moral aspect of the matter, is by no means without its effect upon the laboring poor; but it is most important, as a general rule, among persons of a certain limited degree of mental cultivation. People who are accustomed to some amount of luxury, who possess only scanty intellectual resources, and who are dependent upon their eyes for their various pleasures and amusements, often entertain a fear of blindness which can hardly be described as other than morbid and exaggerated. From the time when they learn that cataract is forming until the time when they are relieved of it by a successful operation, the dread of loss of sight is seldom absent from their thoughts; and this dread disturbs their sleep, haunts their dreams, impairs digestion and assimilation, and lowers the whole tone of their vitality. Its influence may be quite as hurtful as the loss of physical comforts, and it may call for an early

operation as the only means by which an ever present incubus can be removed. On the other hand, there are persons of calm and courageous temperament who can wait for the development of cataract without suffering; and with such it is proper to defer the operation until maturity has been attained in the eye in which the degeneration is most advanced. There can be no advantage in waiting longer than this; and, as one eye is generally ready sooner than its fellow, to operate first upon the former, before the latter is wholly blind, has the great advantage of giving the operated eye a longer period of rest before it is called into use than it would otherwise obtain. If we wait until both eyes are blind, the patient will usually be in great haste to exercise his recovered faculty; and if an eye is used too soon after an operation, before the cicatrix has become thoroughly consolidated, the curvature of the cornea is apt to be injuriously modified by the action of the ciliary muscle and of the recti; not to speak of inflammation and other hurtful consequences which may be produced. But, when the eye which has not been operated upon is still in some degree useful, the other may have a sufficient period of complete rest before its newly recovered powers are exerted. By the time it is actually required it will have so far returned to its normal state as to be fit for any duty which is likely to be imposed upon it.

For the reasons thus briefly set forth, I am accustomed, in the case of patients in independent circumstances and of tranquil minds, to wait until the cataract in one eye has attained maturity, and then to advise an immediate operation, although the cataract in the other eye may be in a comparatively early stage. The exception to this rule would be when the feeble health or the advanced age of the patient rendered it improbable that life would be prolonged until the sight of the second eye was also lost. In a healthy subject of seventy years old, with mature cataract in one eye and advancing cataract in the other, the completion of blindness would be only a question of time, and there could be no doubt as to the propriety of operating upon the eye in which the cataract was mature, so as to gain three benefits; first, that the patient should be relieved, once for all, from the fear of blindness; secondly, that he should never become blind; thirdly, that the operated eye should have time for complete recovery before it was taken into use. But if the patient were eighty or eighty-five instead of seventy, or were suffering from disease likely at no distant time to terminate fatally, then the probabilities would be that the sight of the second eye would be preserved as long as life was spared, and no operation could properly be undertaken. When the advance of cataract implies either physical privation or serious distress of mind, I advise an operation upon the worse eye as soon as either the bodily or mental pinch begins to be felt; and in such cases, by methods hereafter to be described, I do not hesitate to attack a lens in which maturity is still distant. When cataract affects one eye only, the other being wholly free from it, I do not recommend an operation except for the purpose of removing a disfigurement, or in the case

of persons who are moving about among machinery, or who are otherwise so circumstanced that a blind side may be a source of danger to them.

I am well aware that it is the custom of some operators to advise that patients with cataract should wait until maturity has taken place in both eyes, and that then both eyes should be operated upon at once. Such advice appears to me to be in every way unsonnd—to be thoroughly unscientific in its surgical aspects, and not to be calculated to promote the welfare of those who follow it. For, apart from the reasons already advanced in favor of a different practice, the experience gained by an operation upon one eye may enable the surgeon to modify with advantage his plan of proceeding with the other; so that, even when a patient is first seen with both cataracts mature, it is best to allow a week [or two] to elapse between the two extractions, and to see one eye in safety before the other is imperilled. When an operation is undertaken at a still earlier period, the impropriety of dealing with both eyes at once is still more manifest.

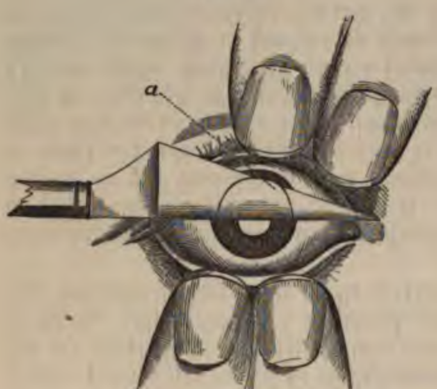
When one eye has been operated upon with entire success, the surgeon has obtained the best possible evidence that there is nothing, either in the local or the constitutional conditions of his patient, to interfere with the attainment of an equally good result in the other eye also. It is then generally desirable to operate on the other eye before the patient enters upon the full fruition of his recovered sight with the first; because otherwise he is apt to be satisfied with the first, to shrink from another period of seclusion and surgical treatment, and to go into the world with the disadvantage of monocular vision and the danger of a blind side. The danger is by no means unreal; for a person in good health, who has been purblind for a period and whose sight has been restored, is generally desirous to make the most of his gain, and to go about with great resolution and activity. He forgets that he sees on one side only, and he falls into holes, or runs against obstacles, in a manner which his remaining infirmity sufficiently explains, and which may sometimes entail upon him grievous injury. When both cataracts are mature it is [generally] the best practice to operate upon the second eye as soon as the safety of the first is assured, and before the patient leaves his room. When the second is still immature, it may, nevertheless, be removed as soon as the first eye has perfectly recovered, and before it has been bought into daily use by the necessary spectacles.

Proceeding now to the choice of an operation, it is manifest that this must be guided, in some degree, by the condition of the lens which it is proposed to remove. In the performance of extraction, the objects of the operator are—1st, to remove the lens, both nucleus and cortex, entirely from the eye; 2d, to effect this removal with the smallest possible amount of injury or disturbance to the remaining parts of the organ; 3d, to leave the most favorable conditions for speedy and uninterrupted healing; 4th, to secure

that the transparency and the curvature of the cornea should be unchanged.

The operation of extraction, as devised by Daviel and improved by Beer, and now commonly known as "flap" extraction, was practiced almost universally, and without important modification, for nearly a century. In this method [Fig. 85], a triangular knife was made to transfix the cornea, the point entering and emerging on the horizontal meridian, about half a line in front of the sclero-corneal junction, and the edge separating just one-half of the cornea as a semicircular flap, which was made upwards or downwards at the pleasure of the operator. The flap being completed, a curved needle was introduced between the lips of the wound, and its point, carefully carried through the pupil, was made to divide the anterior capsule of the lens, and was then withdrawn. Finally, by gentle and carefully regulated pressure of the fingers, the lens was made to turn upon its axis, to dilate the pupil and to pass through it, and finally to escape through the corneal wound. The eye was closed by plaster or bandage, and the surgeon awaited the result. This, in favorable circumstances, left nothing to be desired. The curvature of the cornea was unaltered, the aqueous chamber was fully restored, the line of cicatrix was scarcely visible, the pupil was circular and mobile, and vision, with the aid of an artificial lens to replace the natural one, was restored almost [or, in some cases, quite] to its normal standard.

[Fig. 85.]



While such was the issue of successful cases, there were many others which terminated in a less favorable manner. In some the operation itself was attended by great loss of vitreous humor, followed by wasting of the eyeball, or by intraocular hæmorrhage which was immediately destructive to sight. In others, the iris prolapsed into the wound and became adherent there, a complication which always produced delayed healing and distortion of the pupil, and also, generally speaking, much chronic inflammation of a very painful kind, leading to great impairment or even loss of vision. In others, the cornea sloughed without effort at repair—an occurrence which was usually followed by suppuration of the whole eyeball. In others, acute inflammation, leading to the same consequences, appeared on the first or second day after the performance of the operation.

For many years it was the custom not to open an eye after extraction until at soonest the third, or even until the fifth day, by

which time healing was completed or an unfavorable result was declared. Until then, the occurrence of sloughing or of inflammation was made known only by swelling of the eyelids; and the prevalent idea was that if all were going on well the parts should be left undisturbed as a matter of course; and that, if anything were going wrong, to lift up the lid would only aggravate the evil. As a matter of fact, things did go wrong in a certain proportion of cases—a proportion probably not less than 20 per cent., even in the hands of good operators. The late Professor Von Graefe was not satisfied with this measure of success; and set himself to consider how it might be increased. He saw that the first thing necessary, in order to find out the causes of failure, was to ascertain the point of departure of any destructive or morbid process; and for this purpose he opened the eyes of his patients after operation daily or even more frequently, and carefully examined them by the soft light of a wax candle. He found that inflammation usually originated in the portion of iris opposite to the centre of the flap, that is to say, in the portion which was most stretched and squeezed during the passage of the lens through the pupil; and he suggested that if this portion of iris were excised prior to extraction the rest would be left uninjured, and that the occurrence of iritis would be comparatively rare. This suggestion was first acted upon on a large scale by Dr. Mooren, who performed iridectomy upon a considerable number of cataract patients, and then flap extraction at periods ranging from two to six weeks afterwards. Mooren's results were so successful that his account of them excited some incredulity; and this induced him to publish a pamphlet containing the names and addresses of all the patients who had been operated upon, so that any who pleased might visit and inspect them. While the losses due to inflammation and to prolapse of the iris (manifestly impossible after the iridectomy) were being thus diminished, others who were working in the same direction had observed that the enlargement of the pupil due to the iridectomy would much facilitate the exit of the lens, and would allow this to take place through a smaller external opening than had formerly been required. It was seen that a smaller wound, by reason of its separating the cornea less extensively from its base, would entail a diminished liability to sloughing from default of reparative power; and, in order to do away with injurious pressure in squeezing out the lens through a small opening, various traction instruments were contrived, by which it was to be scooped out, or drawn out, as the case might be. Dr. Waldau (under his original name of Schuft) was the pioneer in this direction; and he was followed by Mr. Critchett, Mr. Bowman, the late Mr. J. Zachariah Laurence, and Dr. C. Bell Taylor, of Nottingham. All these gentlemen either invented traction instruments, or modified those invented by others; but the traction loop or "vectis" of Dr. Taylor (Fig. 86)

FIG. 86.

is the only contrivance of the kind which seems likely to hold a lasting place in the estimation of ophthalmic surgeons. From this time onwards the history of cataract extraction bears a great surgical analogy to the history of ovariotomy; for just as, one by one, the causes of death have been eliminated from the latter operation by careful study and successive setting aside of the conditions which tended to the production of a fatal result, so, in like manner, the causes of failure have been eliminated from the former. Von Graefe, who himself used a traction hook at one period, was not long in discovering that all such instruments were sources of danger, which should be had recourse to only under exceptional conditions; and he then strove to combine an incision so small that it should produce little risk of corneal sloughing, with one so made and so situated that it should permit the exit of the lens without injurious pressure. The result was that method of "modified linear extraction" which was the last of his great contributions to the art he loved so well.

During this period, when real and important changes were being effected in the methods by which cataracts were removed, the surgeons engaged in the work had many followers who made changes which for the most part were only apparent. It is hardly possible for two pairs of human hands, especially if endowed with different degrees of skill, to execute all the steps of a complicated operation precisely in the same way; and so it came about that each of several operators found it more convenient to himself, more suited to the requirements of his own eyes and fingers, to deviate in some minute point of detail from the practice of somebody else, of whom, nevertheless, he was in the main an imitator. Such deviations were often described, in pamphlets or in medical journals, as the "modifications," or even as the "operations," of those who first had recourse to them; and in this way a certain amount of cheap fame appears in some instances to have been secured. Of such changes there were none really worthy of record, or which possessed more than a fleeting and personal interest. They mostly suggested themselves as natural correctives to some kind of manual incapacity; and will suggest themselves again, as it were instinctively, to those who share the defects of dexterity in which they had their origin.

The avowed disciples of Von Graefe were not long in discovering that the operation of their master had left them between two dangers. He taught them to make an incision which was barely anterior to the iris, and altogether in the sclerotic coat;[1] and in following his instructions they sometimes wounded the ciliary region and produced sympathetic ophthalmia of the other eye. In seeking to avoid this risk by an incision in an anterior plane, lying partly or entirely in the cornea, they became liable to cause

[1] [The incision practiced by Von Graefe was in the sclero-corneal junction, where the opaque scleral tissue overlaps a little the transparent cornea, so that externally it appeared to lie wholly in the sclera, but internally wholly in the cornea.]

sloughing of the cornea, and they not unfrequently produced a change in its curvature which required to be corrected by a cylindrical glass. There arose, therefore, much division of opinion with regard to the best place, within narrow limits, for the incision; some operators preferring to keep well back and away from the cornea, while others cared little for the cornea if they could avoid encroaching upon the ciliary region.

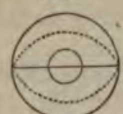
Amid the turmoil of this controversy there appeared one innovator who had the merit of being original. Dr. Küchler, of Darmstadt, in 1868, published a pamphlet in which he advocated a section made across the middle of the cornea in its horizontal diameter. After having extracted the lens through this opening, it was his practice to immobilize the eyelids by enveloping the whole head and face in a sort of helmet of plaster of Paris bandage, which was not removed for several days, and under which he believed that uninterrupted healing would be likely to take place. His publication is a curious example of how much may be said by an ingenious person in defence of a proceeding of which, at first sight, it seems difficult to speak seriously. His arguments are conclusively refuted by his statistics, which extend to twenty-eight cases of his peculiar operation. In this number he had one case of suppuration of the wound, six cases of adhesion of the iris to the cicatrix, seven cases in which the whole of the cortex could not be removed, six cases of loss of vitreous humor, and ten cases in which a second operation was required for the establishment of a pupil. The amount of sight gained by the patients is not stated with exactness; but it is stated that the transverse corneal cicatrices offered no impediment to vision.

From certain internal evidence afforded by Dr. Küchler's pamphlet, I cannot help believing that his love for the transverse section arose from the readiness with which it could be accomplished by the surgeon, rather than from any advantages which it offered to the patient. I am not aware that he has had a single faithful follower; but a few operators have been tempted, possibly by the fatal facility of his procedure, to come very near to it; and among these both Mr. Liebreich and Dr. Warlomont have practiced, and have even advocated, transverse section of the cornea as a first step towards the extraction of cataract.[1] These gentlemen have

[1] [Neither Liebreich, Lebrun, Warlomont, Ed Jäger, nor any recent author, has advocated a "transverse" incision of the cornea. Liebreich has very justly described his incision as a modification of that of Von Graefe (Fig. 94, page 336); both puncture and counter-puncture are in the sclero-corneal junction, about a millimetre outside the margin of the transparent cornea, while the middle of the incision lies rather less than two millimetres within the lower corneal margin. It is, in fact, a low flap, of about the same form as in Von Graefe's operation, but placed a millimetre and a half or two millimetres nearer the horizontal diameter of the cornea. In Lebrun's "median sphero-cylindrical flap," attributed in the text to Dr. Warlomont, the puncture and counter-puncture are made nearly as in the old flap extraction (Fig. 85, page 330), while the centre of the incision lies about opposite the upper margin of the pupil when in a state of median dilatation. Both Liebreich's and Lebrun's incisions (which are very incorrectly indicated in Fig. 87) differ radically from that of Küchler, in that the former describe flaps,

not made their incisions exactly in the horizontal diameter, but they have gone a little above or below it; the black line in Fig. 87 showing the course taken by Küchler; the dotted lines the courses taken by his imitators. Mr. Liebreich has described the incision downwards as constituting his peculiar method; but the incisions both above and below the pupil are mentioned and discussed by Küchler, who advances cogent reasons for preferring the exact diametral line; and who anticipates, in favor of his own operation, all the arguments which have been advanced in favor of the others. It would be a waste of time to examine these arguments, because transverse corneal incisions stand self-condemned on *a priori* grounds. They have the single recommendation that it is very easy to make them; and they might perhaps be attempted with advantage by a benevolent traveller who was sojourning among a savage tribe, or by an ophthalmic surgeon upon whom the infirmities of age were creeping, or by one who was prevented, by the natural quality of ambi-sinistrousness, from employing better methods with ordinary prospects of success. Even in such cases Lord Melbourne's pithy inquiry, "Couldn't you have let it alone?" would be likely to suggest itself to reasonable men. As a matter of first principles, an incision through the front of the cornea must in a large proportion of cases be followed by adhesion of the iris to some part of the cicatrix; and adhesion of the iris, even if vision is for a time restored, entails a perpetual liability to the occurrence of destructive morbid changes In the practice of Dr. Küchler, as I have already stated, adhesion confessedly took place in six eyes out of twenty-eight; and I am told that the same thing has happened in the practice of those English surgeons who have employed Mr. Liebreich's modification of Küchler's method. Moreover, again in a large proportion of cases, such an incision must be followed by alteration of curvature during the healing process; that is to say, by such a distortion of the cornea as to interfere seriously with vision. We see this every now and then in clean corneal wounds made accidentally by broken glass or by some sharp instrument, and in which the lens has escaped injury. It was seen still more frequently a few years ago, when flap extraction was commonly performed, in the cases in which that operation had been badly done. If the edge of the Beer's knife was directed too much forward, the corneal incision, instead of following the course of the dotted line in Fig 88, followed the course of the dark line,

FIG. 87.



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while the latter is strictly linear, and lies in a great circle of the cornea. Both are, moreover, very favorably placed to secure the free and perfect exit of the lens, while Küchler's section, both as regards its form and its position, is perhaps the worst that can be imagined. Both operations are probably positive improvements upon the old method by the semicircular flap, and like it are comparatively easy of performance; both, too, seem to offer especial advantages in their adaptation to certain somewhat exceptional conditions, but neither has yet been shown to promise so large a percentage of successful results as the now classic operation of Von Graefe.]

and the greater the forward inclination of the knife, the nearer to the centre of the cornea was the incision. I was once consulted by an elderly lady who had been operated upon in this manner. Seen from the front, the cicatrix in her cornea was placed as in Fig. 89, and the operation had been followed by iritis, which had fixed the pupil, and had drawn it a little upwards, nearer to the cicatrix than its normal position. Seen in profile, the relations were as in Fig 90; and the degree of corneal distortion in front

FIG. 88.

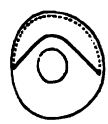


FIG. 89.

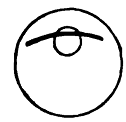


FIG. 90.

of the pupil was such that the extraction of the lens, although it had admitted light to the retina, had given no useful vision. I advised an artificial pupil in a downward direction, as affording good hope of improvement; and the patient consented to the operation. But before it could be performed her mind gave way under her previous disappointment, and she was removed to an asylum, where she died. On all the above grounds I have abstained from seeking any personal experience of transverse corneal sections, feeling that they cannot be said to fall within the boundaries of legitimate surgical experiment.

Another original suggestion, but of a very different character, was that of Dr. Bell Taylor of Nottingham, who endeavored to combine the benefits of iridectomy with the preservation of the integrity of the pupil. For this purpose, after making an incision at the corneal margin, he incised or separated the iris, near its ciliary attachment, to the same extent, and pressed out the lens through the peripheral opening thus made, instead of through the pupil. After this operation, the detached or divided upper part of the iris falls a little, and the pupil becomes somewhat flattened at the top; but this constitutes a comparatively trivial blemish. I have performed Dr. Taylor's operation four or five times, and with good results; but I have nevertheless abandoned it, because I do not think it is calculated to give a large percentage of success. It requires a more protracted and more difficult manipulation than the ordinary methods, and it takes up more time. There is, therefore a longer period during which some accident—such as loss of vitreous from spasm of the ocular muscles—is liable to occur; and on this account I feel sure that, if the method became general, the number of failures, or of only partial successes, would be comparatively large. Moreover, the increased risk does not appear to me to be attended by any corresponding advantage. The excision of

a piece of iris in the ordinary way does not diminish the acuteness of vision; and the gap in most cases, is completely veiled by the upper lid. Even if this were not the case, and in persons in whom the eyeballs are naturally prominent, the appearance of the eyes after any form of cataract operation is much concealed by the powerful convex lenses which it is always necessary to wear.

The first procedure in cataract extraction is obviously the division of some part of the outer tunic of the eye, and Von Graefe has felicitously pointed out the nature of the differences which underlie the different forms of section. An incision wholly situated in any plane which would pass through the centre of the eyeball forms, it is manifest, a portion of a larger circle than an incision in any plane which would not pass through this centre; and also possesses over the latter the advantage of being less liable to gape or open spontaneously. The incision of the old flap extraction is in a plane far anterior to the centre, as shown by the dark line in Fig. 91, while the incision in Von Graefe's modified [peripheral] linear method is [more nearly] in a plane passing through the centre, as shown by the dark line in Fig. 92. The larger the circle of which the section forms part, the smaller proportion need the section itself bear to the circumference as a whole; and thus, while the section for flap extraction is [rather more than] a semicircle, that for Von Graefe's method is little more than the third of a semicircle. Fig. 93 shows the relative proportions of the two, with some exaggeration of the latter; and it is evident that the former, with reference to its position, is a much more serious injury than the latter. But

FIG. 91.

FIG. 92.

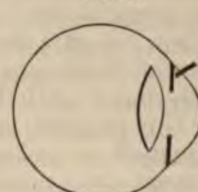
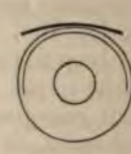


FIG. 93.

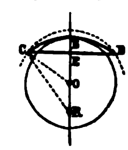


[FIG. 94.]

in order that Von Graefe's incision [Fig. 94] should avoid the cornea, and should at the same time [approximately] preserve the direction of a plane passing from the margin of the cornea through the centre of the eyeball, it became necessary that its extremities should lie very near to the ciliary region; and hence arose the danger, already mentioned, of inflicting an injury liable to be followed by cyclitis and irido-choroiditis in the eye which was operated upon, and by sympathetic ophthalmia in its fellow. In order to avoid these risks, many operators prefer a somewhat more extended incision in an anterior plane, not, as in the old method, in a plane parallel to the iris, but in one which, although inclined with reference to the iris, would not pass through the centre of the globe. In this preference I myself concur, and perhaps

the best rules for making such an incision are those which have been laid down by M. de Wecker [Fig. 95]. I do not think, however, that an experienced operator will allow himself to be very closely bound by any rules of procedure, but he will vary every operation a little, in accordance with the size and prominence of the eye, the position of the cornea, and the estimated size of the hard nucleus of the lens. In cases in which the cataract is mature, and no preliminary proceeding of any kind is required, I perform extraction in the following manner.

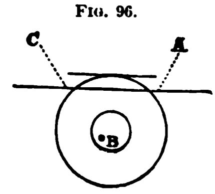
[Fig. 95.]



[De Wecker's diagram illustrating the form and position of the incision in peripheral-linear extraction. O B = 6 mm., O C = 7 mm., O E = 4 mm., E B = 2 mm., R C = 9¼ mm., C D = 11½ mm.]

The patient being recumbent upon a convenient couch or table, and fully under the influence of ether, the eyelids are separated by the speculum shown on page 148, which is fixed in such a way that its palpebral portions can exert no pressure upon the globe. A linear knife, which should have a blade thirty millimetres long, two broad, and as thin as is compatible with the necessary rigidity, is held in the right hand for the right eye, and in the left hand for the left, the operator standing behind the head of the patient. The eyeball is secured, either by the double fixation hook or by the perforating forceps, at a point exactly opposite the centre of the intended incision, that is to say, generally speaking, about half a line from the lower margin of the cornea on the vertical meridian. The point of the knife is then entered, just behind the margin of the cornea, on a line two millimetres below the horizontal tangent, as at A in Fig. 96. As in all punctures, the direction of the thrust is towards the centre of the eyeball until the anterior chamber is entered, when the point is turned so as to descend, in a direction parallel with the plane of the iris, to about the position B. When this is reached, the handle is depressed, turning upon the back of the blade in the incision, until the point is brought to C on the same horizontal line as the puncture. When this is reached, the handle must be inclined somewhat backwards, and the point pushed on with a quick movement, so that it may transfix both sclerotic and conjunctiva at its place of first impact, without gliding backwards, as it is apt to do if pushed slowly. In this way we obtain a puncture and counter-puncture which are both a little behind the true cornea, but which are well in front of the ciliary body; and if the knife has been rightly held its cutting edge is directed upwards, towards the operator, and its flat surfaces are parallel to the plane of the iris. The fixation instrument may now be laid aside, and a very slight movement of rotation given to the knife, so as to turn its edge a little forwards, and to permit the escape of some of the aqueous humor. The incision should then be completed by a succession of gentle drawing cuts, the blade

Fig. 96.



being thrust back as often as necessary, and being made to cut only during withdrawal. The rotation of the edge forwards should be just sufficient to make the centre of the incision correspond exactly with the sclero-corneal junction, so that its whole track will lie in a plane which is oblique, but less oblique than, and altogether anterior to, the plane of Von Graefe's section. The last part of the cornea should be divided with extreme care and gentleness, and if the patient has for any reason not been placed under an anæsthetic, it is necessary to wait, sometimes for a few seconds, before completing the section, in order to allow of the subsidence of any spasm of the recti muscles. If the knife is very keen, the conjunctiva will fall apart before its edge; but in many cases this membrane will stretch a little, and it may then with advantage be cut somewhat farther back, so as to form a flap which will cover the corneo-sclerotic wound. The completion of the section finishes the first act of the operation.

The next thing to be done is the iridectomy; and upon this too much care can hardly be bestowed. It must be remembered that the object in view is not to produce a large coloboma, but simply to destroy the resistance of the sphincter pupillæ to the exit of the lens. If traction is exerted upon the iris, the portion left behind is apt to be entangled in the ends of the section, and to become adherent in this position during healing—a state of things which is always dangerous and often destructive. In order to avoid such an event, the operator should seize the iris with forceps opposite the centre of the incision, and should hold a pair of Noyes's scissors (Fig. 53, p. 162), or of common iris scissors, with their blades in contact with the ocular surface, and ready to be closed upon the piece of iris which is drawn out, as soon as there is room to close them between the forceps and the eye. The best forceps are the simplest, such as those shown in Fig. 48, page 158, with a curvature to clear the brow, and with teeth directed backwards, at right angles to the axis of the blades. But any forceps will do, so long as the iris is neither dragged nor put upon the stretch, nor cut close to the angles of the external incision. With complete anæsthesia, the patient will often be so passive that no fixation will be needed during the iridectomy, especially if the operator is certain of his own power to follow any roll of the eye, however unexpected, with the forceps hand, so that the iris shall not be put upon the stretch. But I have seen half the iris torn away from its attachments by a movement for which the operator was not prepared; and it is therefore always better that a beginner should have the eye fixed for him by an assistant. For this purpose, the toothed forceps for the conjunctiva (Fig. 41, page 150), form the best implement, and it does not much matter to what part of the globe they are applied, the chief thing being to keep the assistant's hand out of the way. It is necessary that the assistant should know clearly that this duty may devolve upon him, and that he should understand the way in which it must be performed; a point which has been already sufficiently dwelt upon

in the fifth chapter. If the anæsthesia is incomplete, the operator, however skilful, will not be able to dispense with such assistance; because then the tendency of the levator palpebræ [rectus superior] will be to roll the eyeball upwards under the shelter of the upper lid, and thus to place the external wound securely under cover. If this tendency is at all strongly declared, no prudent surgeon will allow his assistant to drag down the eyeball in spite of it, because the struggle between the opposing forces would be almost certain to rupture the hyaloid membrane and to permit the loss of vitreous, an accident which, when it happens prior to the exit of the lens, should always be regarded with grave concern. If the section of the iris is properly made, there will be little or no bleeding from the cut surfaces, and the angles formed between the terminations of the incision and the margin of the pupil should be

FIG. 97.

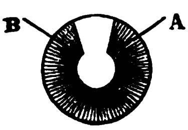
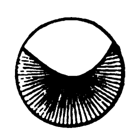


FIG. 98.



plainly visible within the anterior chamber; the coloboma presenting the appearance of Fig. 97, in which A and B are the angles referred to. If, on the other hand, the iris is dragged out, and cut close to the ends of the corneal wound, the appearance will be more like that of Fig. 98; and then the probabitities are that, when healing is nearly completed, a dark spot or projection at one or both of the extremities of the cicatrix will show the presence of incarcerated iris. The liability to hæmorrhage, also, will be much increased, and the anterior chamber will sometimes become filled with blood, which will conceal everything else from view. Whenever this occurs, and whether it is due to a faulty iridectomy or to unusual vascularity of the tissues, the blood should be removed, wholly or in great part, before the operation is proceeded with. For this purpose a little gentle pressure or stroking of the cornea from below upwards, with the back of the vulcanite spoon which is used to extrude the lens, will generally be an effectual manœuvre; and the blood which is ready to escape by the outer wound should be further solicited to do so by the very careful application of a soft fragment of moistened sponge. If the chamber fills again, the eyelids may be suffered to close, and a larger sponge dipped in cold or iced water may be laid over them for as long as may be necessary; but this expedient is very seldom required. When the blood has been sufficiently removed to render the pupillary area clearly visible, the operator proceeds to the next step, the laceration of the anterior capsule of the lens.

For this proceeding, which was until lately accomplished by means of a slightly curved needle, or by Von Graefe's "fleam-shaped" cystitome (shown on the same handle with the curette in Fig. 83,

page 316), M. de Wecker has lately contrived an instrument that presents many advantages, and that is represented in Fig. 99. It may be described as a double fleam-shaped cystitome, the two parts of which are placed upon the two branches of a pair of iris forceps furnished with terminal teeth, and with a regulating screw to limit the extent of their opening. The forceps are introduced closed

Fig. 99.

into the anterior chamber, the cystitome blades being kept well up into the concavity of the cornea, and the forceps themselves being held horizontally, until their extremities pass somewhat under the margin of the pupil on the side opposite to the incision. When this position is reached, the handles of the forceps must be gently raised into a vertical direction, and the cystitome blades brought into contact with the anterior capsule, and caused to penetrate it. At the same moment gentle pressure may be made with the fixation forceps, in order to project the lens somewhat forwards. As soon as the capsule is pierced, the operator permits the cystitome blades to open as far as the previously adjusted regulating screw will allow. As soon as they are open, he draws them gently towards him nearly to the margin of the lens, and then closes them, at the same time making a dip into the cortex with them as they shut. The general result of this proceeding, simple in itself but difficult to describe, is that the fleam-shaped points cut out a large quadrangular piece of the anterior capsule, and the forceps teeth seize this piece and bring it out of the eye. Until perfectly accustomed to the instrument, it is necessary for the operator to use the greatest care in its introduction. Without such care, it is very easy to entangle the cystitome points in the cortex, and to push the lens before them, rupturing the suspensory ligament or the hyaloid membrane, and doing great and dangerous mischief. The way to avoid this is to keep the points well up towards the cornea, and to depress the handles even below the horizontal line, until a point beyond the centre of the lens has been safely reached.

When M. de Wecker's cystitome is not at hand, any of the common instruments will suffice for the laceration of the capsule, although none of them will with the same certainty bring away the central piece. In introducing a needle or other simple cystitome, care must be taken always to keep its blunt part forwards until the point reaches the portion of capsule which is to be first attacked ; and the instrument must be withdrawn with similar precaution. Many writers have laid down rules for the laceration of the capsule, but the only important ones are that it should be done with sufficient freedom, with a light hand, and with careful

avoidance of injury to the iris or other structures. The most usual plan is to carry the point of the instrument just under the pupillary margin, and to divide the capsule from there to the outer angle of the external wound. The point is then gently carried back to the commencement of the first incision, and a second one is made from the same place to the inner angle of the wound. A third unites the two foregoing along the margin of the lens, in the direction of the external wound; and then, before the cystitome is withdrawn, its point may be stuck into the nucleus, and may be made to impress upon this a slight movement of rotation about its antero-posterior axis, so as to feel that it is loose and ready to escape from the eye.[1] As soon as the capsule is divided there is usually an escape of cortical substance, more or less in quantity according to the degree of softening which it has undergone.

The operator next seizes the conjunctiva by toothed forceps on the inner side of the cornea, somewhat lower than the horizontal meridian, and applies the convexity of a small curved spoon of hard vulcanite below the cornea, at the original point of fixation. With this spoon he makes steady, gentle pressure, at first in a direction towards the centre of the eyeball, and, if all be well, the upper margin of the nucleus will presently advance into the wound. As it does so, the spoon must be moved steadily upwards so as to keep pace with it; and when the centre of the nucleus is fairly engaged in the lips of the wound, the spoon may be made to glide quite quickly over the cornea, stroking out, so to speak, any cortex which may have been left behind, and receiving the nucleus in its concavity.

As soon as the nucleus is removed, together with any loose cortical matter which may lie about the edges of the wound, the speculum may be taken out, and the lids suffered to close. With the pulp of one finger the operator then makes gentle rotatory pressure, through the upper lid, upon the cornea, a manœuvre which tends to replace the iris if any part of it has been pushed out before the lens, and also to gather together, into the pupillary area, any fragments of cortex remaining in the eye. After a few moments, the lid may be gently raised and the eye examined. Small coagula, lying under the lids or about the lips of the wound, should be carefully picked away with fine forceps; and if there is any cortex left behind, it should be removed by gentle and suitably directed pressure upon the cornea with the spoon. If consciousness is sufficiently restored, valuable evidence that all the cortex has been extruded may be obtained by testing vision. The patient should be able to count fingers, and to distinguish the thumb from the little finger; and if he cannot do so, the rotatory friction and the pressure should be continued. When the pupil is clear and black, and the edges of the wound are clean, the conjunctival flap, if one was made, must be carefully placed in its

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[1] [This last manœuvre is hardly requisite, and may lead to accidental dislocation of the lens.]

right position, and the lids closed and secured with a compressive bandage.

If the nucleus does not advance readily when the spoon is first applied below the cornea, and especially if a transparent bead of vitreous, covered by hyaloid membrane, is seen to bulge into the wound under the pressure, this pressure must neither be increased nor continued; but the operator must pause and consider what is the condition which opposes the exit of the lens. It may be that the capsule has been insufficiently divided, or that the external incision is too small; or that the pressure has been misdirected; and to these possibilities I would add, that a small hard nucleus, which has been surrounded by a large quantity of soft degenerated cortex, sometimes seems to elude the effect of pressure by its want of magnitude, and thus to remain somewhat obstinately within the eye. The operator, in the first instance, should proceed to divide the capsule once more, and should then renew his pressure with great precaution and tenderness. If the lens still does not advance, he may next carefully examine the size of the section, and may enlarge it if there seem to be necessity, always remembering that it is better to have the wound too large than too small. The enlargement is best effected by a single cut from a pair of fine scissors, somewhat blunt-pointed. One point should be glided along, as far as may be necessary, between the iris and the cornea, at whichever end of the wound is most easily accessible; and the cut should be made in the sclero-corneal junction. The scissors should be pushed a little beyond the point to which it is desired that their cut should extend; for the firm and elastic corneal tissue has a tendency to slip from between the blades as they are being closed. The cut being sufficient, another gentle application of pressure may be made, and will then generally be successful.

If the operator is quite sure that the incision is completely made and of the proper length, and that the capsule is sufficiently divided, and if the nucleus still does not advance, more especially if there should be actual rupture of the hyaloid membrane and escape of vitreous, either in its natural state or diffluent from disease or degeneration, it becomes necessary to have recourse to a traction instrument without delay; the object being to remove the lens before the loss of vitreous is sufficient to imperil vision. I have already said that several traction instruments have been invented; but there is none which seems to me to combine so many advantages as the loop, or "vectis," of Dr. Taylor, already shown in Fig. 86, page 331. Many makers have an imitation of this vectis upon a faulty model; with too great thickness of metal both in loop and shaft, and with the loop curved or bent upon itself. It is essential to the perfection of the instrument that it should be very fine and slender in all its parts, and that the loop, though joined to the shaft at an angle, should itself be all in the same plane. In using it the operator should hold it very lightly, and should fix the globe with forceps, rather restraining the natural

tendency to rotation upwards than causing any movement of rotation downwards, by which a still greater escape of vitreous would probably be occasioned. The manipulation of the loop itself must be varied to meet the circumstances of each case. If the vitreous is firm and healthy, and not escaping, or if the amount lost is only small, the loop may be made to find its way along, and, so to speak, around, the posterior surface of the lens, the operator feeling this surface, but with extreme steadiness and gentleness, as he proceeds, and at the same time watching the lens through the pupil, in order to be certain that it is not displaced by the loop and pushed into the vitreous. If, on the contrary, the vitreous is of watery or syrupy consistence, or is escaping freely, the loop should be directed towards the centre of the eyeball, clear of and behind the lens, until it is gone well past the posterior pole of the nucleus. The handle must then be inclined backwards while the instrument is pushed on, until at last, in either case, the loop embraces the nucleus, the posterior pole of which will then project through the fenestra. The operator must next lift the nucleus out of its bed into contact with the posterior surface of the cornea, and must proceed to extract slowly and gently, keeping the handle of the vectis well back towards the brow, and holding the lower margin of the lens close up to the cornea.

Whenever vitreous has been lost, whether a traction instrument has been required or not, there will almost always be more or less cortex left behind within the eye; and one of the nicest questions in ophthalmic surgery is to determine when this cortex should be left to nature or to subsequent operative proceedings, and when every endeavor should be made to remove it at the time. Experience teaches that fragments of lenticular matter which become surrounded by, and so to speak coated with, firm vitreous, are protected against absorption to a great extent; and that they remain for long periods within the eye, often causing iritis of an intractable or destructive character. On the other hand, when the vitreous is fluid, absorption of cortex usually takes place more rapidly and with less irritation; although the eye in such circumstances, being already unhealthy, is perhaps more liable to suffer. Under the method of flap extraction, escape of vitreous was always a formidable complication, because the size and situation of the wound were such that the loss usually went on for some hours; while the iris was almost necessarily lifted into the wound by the outflow, so that delayed healing and distortion of the pupil were inevitable results. But after an iridectomy the loss of vitreous does not disturb the remaining portion of the iris, and the wound made by modified linear extraction is such that it can be accurately closed by the upper lid and a compressive bandage, and any further drain thus effectually prevented. The loss of vitreous is therefore a much less formidable accident than it was once justly considered; and though it is always to be regretted, and to be avoided whenever possible, yet it does not, unless very large in quantity, necessarily entail any subsequent impairment of

vision. It is said that the healthy vitreous, if partially lost, is never replaced, but that the void is filled up by transparent liquid; and that this, even after complete healing, is liable to undergo sudden variations in quantity, which produce corresponding variations in the tension of the eyeball. An abnormally fluid vitreous is replaced by a liquid undistinguishable from that which was lost; and in some cases, when the eyeball has been almost emptied, the original quantity of fluid is fully restored. But a great loss of vitreous involves two principal risks,—the first being intraocular hæmorrhage, due to rupture of a choroidal vessel from which support has been suddenly withdrawn, an accident by which vision is at once and finally extinguished; the second being wasting or atrophy of the eye from the shock to its nutrition. The general result of these considerations is that the operator must neither suffer any large quantity of cortical substance, such as might be removed by a scoop or a suction curette, to remain in the eye for the sake of avoiding a loss of vitreous which would probably be trifling in amount; nor, on the other hand, must he risk a copious loss for the sake of removing every cortical fragment. Another element in the question is that prolonged manipulation of a wounded eye, and more especially the frequent introduction of instruments, are in themselves sources of danger; and, taking ophthalmic operations generally, I believe that long experience confers no greater advantage upon the surgeon than in teaching him to perceive and recognize his opportunities of leaving off, and of letting well alone. I have more than once seen disastrous consequences brought about by the determination to put yet a finishing touch to something which was already fairly done.

The cause of loss of vitreous, whether it occurs prior or subsequently to the exit of the lens, may be in the act of the surgeon himself, as when the eyeball is rotated downwards too suddenly or too forcibly; or sometimes (the hyaloid membrane being presumably weak), although there is no more suddenness or force of rotation than is usual, the membrane may give way at a point corresponding with the external wound, and may suffer the humor to escape.[1] But in the supine posture, and with muscles relaxed, no great amount of escape can thus be brought about; and it may be said, as a general rule, that large losses are almost always due to spasm of the external muscles of the eye. If the surgeon perceives any tendency to such spasm, he should remove the speculum, cover the closed lids with a soft ball of elastic cotton-wool, and maintain over this with the palm of his hand a gentle and uniform support, which must be hardly pressure, while a more profound anæsthesia is being produced, and the muscles are thus being brought into complete relaxation, so that the operation may be safely proceeded with. If vitreous has actually been lost, the same precaution should be taken; and only when the patient

[1] [Loss of vitreous is especially prone to occur in very prominent eyes, as in myopia of high grade.]

is absolutely quiet, with all reflex action abolished, should the speculum again be applied, and the eye examined. If the vitreous is firm, and portions of cortex are visible in the pupillary field, no attempt must be made to remove them by pressure, but only by a curette, or suction tube, or even by a pair of forceps, very delicately and carefully introduced; and the curette may be used to clean the edges of the wound. The operator should be guided, with regard to perseverance in such endeavors, by the results which attend upon them. If he succeeds in removing fragment after fragment, and if the continued outflow of vitreous is unimportant in quantity, he may proceed until the state of the pupil satisfies him. But if the fragments elude him, and the vitreous escapes freely, and more especially if it wells out in a manner to denote muscular action, the sooner the eye is closed the better. Before closing it, any projecting mass of vitreous must be carefully cut off with scissors close to the surface of the eyeball, so as to remove the hyaloid membrane which may form part of the protrusion, and which would be liable, by separating the lips of the wound, to place an obstacle in the way of their speedy union.[1] If the vitreous is fluid, and running away easily, the remaining cortex may be neglected, and the eye secured; and in every case in which loss has occurred the compressive bandage must be applied so firmly [only] as to afford complete and steady support to the eyes, and to render them comparatively immovable, while at the same time it preserves the edges of the wound in perfect apposition.

The accident of intraocular hæmorrhage from a choroidal vessel, to which reference has already been made as an occasional consequence of a sudden and large escape of vitreous, is one which I have never witnessed excepting in the operation of flap extraction; but which might doubtless occur after any of the forms of transverse corneal section, and perhaps after a section of any kind in an eye which was the subject of choroidal degeneration or disease. It declares itself by an oozing of blood from the eyeball after the removal of the cataract; an oozing which first pushes forward the vitreous, and then shows itself as a coagulum opening the wound. The hæmorrhage not only detaches the retina from the choroid, and thus destroys the eye as an organ of vision, but it also fills and distends the sclerotic, and occasions intense pain, followed by tedious inflammation and suppuration. In order to anticipate these consequences it is desirable, whenever the escape of the lens is followed by bleeding from behind the vitreous, to enucleate the eyeball without delay, while the patient is still under the influence of an anæsthetic. An alternative course, which would have the sole advantage of leaving a better stump for an artificial eye, would be to remove only the anterior portion of the globe, including the ciliary region, to apply a small sponge soaked in solution of perchloride of iron to the sclerotic

[1] [Arlt advises that a protruding bead of vitreous be left, rather than to run any risk of causing further protrusion by the attempt to cut it off; the prolapsed portion is often drawn back into the globe in the course of a few hours, and the healing of the wound is not hindered. See Arlt, *Graefe und Saemisch, Handbuch*, III, p. 305.]

cavity, and to retain it there, by the firm pressure of a bandage over sponge compresses, until all tendency to bleeding had ceased.[1]

When the extraction of cataract is completed, the patient must be carefully and closely watched by a nurse or some intelligent person until the effect of the anæsthetic has so far passed away that consciousness is fully restored. If this precaution is neglected, the bandage may be torn off, or the eye struck or otherwise injured, while a state of semi-narcotism continues. When perfectly recovered, the patient should be enjoined to remain still and quiet; and food or drink should be given or withheld as circumstances may indicate. The surgeon should make his first visit about six or eight hours after the operation; by which time, if all is going on well, the pain felt on restoration to consciousness will have greatly subsided. The bandage should be examined, and, if necessary, readjusted; and if its pressure is a matter of complaint it may be somewhat relaxed; but if it is well in place, and the eye comfortable, it is better left alone. An anodyne should be prescribed—usually either chloral hydrate or morphia, and the latter by preference if there is pain—to be taken only if required; and a "night-cap," in the shape of a little spirit and water, or negus, may sometimes be recommended. The second visit should be made about twenty-four hours after the operation. If the eye is generally comfortable, and there is no worse complaint than of slight occasional pain attended by some escape of fluid, everything may be left alone for twelve hours longer; but if there is permanent uneasiness the bandage must be removed and reapplied, and if the course of the operation was in any respect abnormal, or if the upper lid is in the least swollen, it should be gently raised, and the eye examined by the light of a single candle in an otherwise darkened room. It is not always necessary to look at the wound, but only at the lower part of the cornea and of the pupillary space. If all is well, the surface of the upper lid will be perfectly natural, the cornea clear and bright, the fibrous structure of the iris visible, the conjunctiva not swollen and only moderately injected, and the discharge trifling in quantity, consisting of a small overflow of aqueous humor, together with tears and conjunctival mucus. If no soft matter was left behind, the pupil should be clear and black; but if the cortex was not entirely evacuated, the pupil will be more or less occupied by whitish flocculent material.

In contrast to these favorable conditions, especially on the second day after the operation, the upper lid may be tumid, or with some of its natural wrinkles effaced, and the discharge may be too great in quantity, and of a purulent or muco purulent character. When the lid is raised, the conjunctiva may be found more or less chemosed, the cornea more or less cloudy and concealing the iris, and infiltrated with pus in the neighborhood of the wound. As long as there is not more than this, there is still hope of saving the eye,

[1] [It is better to avoid the use of perchloride of iron if possible, for fear of causing adhesions or contraction of the conjunctival sac, an accident which, as we have witnessed, may interfere with the subsequent wearing of an artificial eye.]

although it is exposed to extreme risk of a twofold character. The suppuration of the cornea may pass on to complete sloughing of that membrane, or it may spread by contiguity to the iris, and in either case it will excite suppuration of the eyeball generally. If the purulent infiltration should encircle the cornea, instead of being limited to the parts about the wound, or if the cornea generally is not merely hazy, but opaque, all expectation of a successful issue must be abandoned. So long, however, as there is no evidence of pus in the anterior chamber, and so long as the manifest changes over the lower half of the cornea do not exceed the limits of superficial epithelial swelling or disturbance, so long treatment may be employed with a prospect of benefit. It is hopeless to attempt to combat the asthenic inflammation by any "antiphlogistic" means; and the plan advocated, and sometimes successfully practiced, by Von Graefe, resolved itself into compression and hot fomentations. The compressive bandage was firmly applied over more carefully adjusted padding than usual; and was removed for half an hour every four hours, in order to make way for a bag of boiled chamomile flowers as hot as they could be borne. Under the employment of this method the suppurative process has sometimes been checked, the discharge has subsided, and healing of the wound has taken place, leaving a closed pupil to be remedied by a subsequent operation. In England, fortunately, suppuration of the cornea is a rare event, which is scarcely ever produced except by the influence of an overwhelming predisposition; and I have not for many years seen a case of it which was not complete and hopeless from the first. But on the Continent, where there is a greater tendency to suppuration among the poorly fed classes, many surgeons have lately advocated the local application of solutions of quinine; and, in addition to this and to Von Graefe's treatment, I should be disposed to have recourse to the administration of quinine hypodermically, and to the use of suitable doses of alcohol. Dr. Braun, of Moscow, has published within the last few years the remarkable statement that at one time he lost 45 per cent of his cataract extractions in hospital by sloughing and low forms of inflammation, the patients being, of course, the badly nourished Russian peasantry. He then commenced the systematic administration of alcohol in regular doses, a few days before the operation, and continued it until the ultimate result was declared. In the first year he reduced his losses to 15 per cent., thus saving two-thirds of the eyes which would previously have perished: and in subsequent years he obtained still better results. It seems to follow that feeble and marastic patients should be prepared for cataract extraction by a period of good diet and tonic medicines; and that they should take a little alcohol daily both before and after the operation. If any threatening of suppuration should appear, a drop of the solution of hydrochlorate of quinine (in the strength of two grains to the ounce of distilled water, with a single minim of dilute hydrochloric acid) should be placed within the lids every four hours; and careful pressure should be alter-

nated with hot fomentations. If the condition of the eye should be manifestly hopeless, the swelling of the lids increasing, and the cornea becoming universally opaque, free incisions should be made through the sclerotic between the muscles, in order to diminish tension, relieve pain, and permit the escape of pus and sloughs. If matters should mend, the discharge diminishing and returning to a mucous character, the swelling subsiding, the wound healing, and a portion of the cornea retaining its transparency, then the treatment already indicated should be continued until convalescence is established, in the hope that an artificial pupil may ultimately restore [in some measure] the sight which has been so much jeopardized.

In the operation which has been described it may be said, as a general rule, if no iris is left entangled in the extremities of the wound, and if the whole of the cortex is removed, that healing by primary union will take place without pain or irritation, and that excellent vision will be obtained. If, on the contrary, the iris should be entangled as described, or if any cortical substance is left behind, either because, being still transparent, it eludes observation, or because an escape of vitreous interferes with its removal, then although an ultimately successful issue may in most cases be expected, yet this issue is only arrived at after a period of more or less severe and protracted irritation and delayed healing, which is often attended by iritis, and which in some cases leads to wasting of the eyeball and loss of sight. The iritis is seldom of a severe character; but it is nearly always attended by the formation of membranes in the pupil which require a second operation for their removal; and the delayed healing, which causes the lips of the section to be separated by lymph, and thus gives a perceptible width to the cicatrix, nearly always alters the vertical curvature of the cornea, and produces a degree of astigmatism which may be corrected by a cylindrical glass if recognized, but which, if not recognized, greatly interferes with the acutenes of vision. In order to guard as much as possible against these complications, it is in the first place desirable to make every endeavor to leave the iris perfectly free within the anterior chamber. The best method of making the iridectomy has already been described; but however well this part of the operation has been done, the cut extremities will sometimes be pushed out by the advancing lens, and will be left in the corners of the incision. When there has been no loss of vitreous, the position of the iris should be looked at before closing the lids, when the cortex has been as far as possible removed. If any prolapse is discovered, it may sometimes be reduced by the extremity of a probe, or by stroking the corners of the wound with the back of the vulcanite spoon; or it may be taken hold of with fine iris forceps, the sharp teeth of which have been filed off, and gently replaced within the anterior chamber. If none of these methods succeed, the prolapse may be excised, for which purpose it must be seized with ordinary iris forceps and cut away with scissors. The finest scissors of Noyes's pattern [Fig. 53, page 162,

or De Wecker's iris scissors, Fig. 66, page 259], will be found the best for this purpose, and their points must be inserted fairly within the lips of the wound. Excepting in a patient of extraordinary steadiness, forceps should only be applied to prolapsed iris under complete anæsthesia, since otherwise a movement of the eyeball might lead to an extensive detachment of the remaining portions of the membrane. If there should be loss of vitreous, a prolapse of the iris must usually be left for subsequent treatment.

In all cases, and more especially if the course of the extraction was in any way abnormal, or if it was either known or suspected that any portion of cortex was left behind, it is desirable, after the second day, to examine the eye daily for at least a week from the time of the operation. For this purpose the patient, being comfortably seated in a darkened room, the pad and bandage being removed, and the edges of the lids freed from adherent secretion by the careful use of a morsel of sponge wetted with warm water, should be told to look downwards, keeping both eyes still closed. The surgeon may then carefully raise the upper lid of the eye operated upon, and may make his inspection by the light of a single candle. If all is well the edges of the wound will be in apposition, the conjunctiva only slightly congested, and the pupillary space bright and black. The bandage must be immediately reapplied; and, if any of the conditions are less favorable (especially if the wound should be at all open, or if vitreous should be escaping), it must be reapplied in such a manner as to give firm and carefully regulated support. On the third or fourth day after the operation, if the conjunctival redness is in excess, if there is entangled iris at the extremities of the wound, or if any cortical substance is visible in the pupil, a drop of a four-grain solution of atropine should be instilled when the compress is removed, and should be repeated at least daily until all irritation is subsiding or has disappeared. As a rule, the compressive bandage may be laid aside during the daytime after the fourth or fifth day, and the eyes may be screened from light by a large paper shade; but the bandage should be worn at night for at least a week longer, in order to afford support to the vessels against the greater tendency to congestion which is incidental to the recumbent posture. At any time during recovery, if there should be manifest iritis, a leech or two may be applied to the temporal region near the margin of the orbit, and atropine may be used three times a day; but no benefit is to be expected from the employment of mercury. If irritation is manifestly kept up by the presence of cortex, this may be removed by the very careful use of a suction-curette through a small opening. If the iris is entangled in the extremities of the wound, and the entangled portions project as little prominences distended by aqueous humor, they may be pricked with a cataract needle and suffered to collapse, after which they may be touched, in the lightest possible way, with a point of diluted nitrate of silver. If the prolapsed portion should again become distended, the best plan is to sever its connection with the main body of the iris.

This may be done by a single thrust of a two-edged cutting-needle, entered at the corneal margin immediately below the projection, and directed from before backwards, and a very little downwards, so that its point may not injure the ciliary body or processes. During the course of all such contingencies as those now under consideration the general health should be supported, quinine should usually be administered, pain should be controlled, and such local applications as afford the greatest amount of comfort should be employed. If the irritation should pass into a chronic state and the conjunctiva should be much swollen or congested, the solution of quinine may generally be instilled with advantage, or the lower retrotarsal fold may be carefully touched with an astringent. If the edges of the lids become sore and tumid, they may be pencilled once a day with a solution of nitrate of silver of from two to ten grains to the ounce, and afterwards anointed with some simple cerate.

There are few more troublesome complications in these cases than spasm of the orbicularis muscle, producing inversion of the lower lid, and contact of its lashes with the globe. It is theoretically easy to overcome the inversion by strips of sticking-plaster, or by painting the cheek with contractile collodion; and such means may for a short time be tried. I have seldom found them successful; and the earlier a strip of skin and subjacent muscle is removed from the lower lid, the more reason will the surgeon generally have to congratulate himself upon the course which he has pursued. The strip should be very narrow, or its removal may produce eventual ectropium; but it should be as near as possible to the tarsal margin, and should include the muscle down to the cartilage. A single fine suture may be placed in the middle of the wound; but it is not very material whether this is done or omitted.

Severe iritis after cataract extraction may extend to the choroid and eyeball generally, and may terminate in wasting of the globe. Such an issue, however, is not very common; and recovery generally takes place, leaving an organ more or less damaged, and a pupil more or less occluded by false membranes. If these membranes are delicate they may be lacerated with two needles, according to Mr. Bowman's method, already described [or with a single needle]; and if the iritis has been trifling, or scarcely perceptible, and has soon subsided, this secondary operation may be done within a month or six weeks of the primary one. In some instances the contraction of the membranes drags upon the iris and maintains a state of chronic inflammation, and then their division or removal can hardly be undertaken too soon; but whenever the eye is improving, it is better to let it forget its first troubles before it is called upon to undergo fresh ones. When needles can be used, it is generally practicable to form with them an opening in the situation of the natural pupil, leaving undisturbed any adventitious formation which may occupy the gap in the iris, and may to some extent remove any optical disadvantages which this gap might otherwise occasion. When the membranes are tough, and formed from a large original deposition of lymph, it is usually desirable to remove part or the whole of them from the eye. This may

sometimes be done by a simple iridectomy, downwards, or downwards and inwards; but the iridectomy often reveals opacities which are more deeply situated, and hence, where there has been much inflammation, it is generally better to cut out the central mass of iris, lymph, and capsule, prior to any attempt to remove it. Operations for this purpose have been devised and perfected both by Mr. Bowman and by M. de Wecker.[1] In Mr. Bowman's method a broad lance-knife is pushed through the corneo-scleral junction and iris as near to the ciliary margin of the latter as possible. Fine scissors are then introduced, with one blade in front of the iris and one behind it, are carried to one extremity of the wound, and are made to divide the iris and adventitious membranes to a point just beyond the further margin of the natural pupil. The scissors are then moved to the other extremity of the wound, from whence they make a second cut, converging to and meeting the first, so that the two scissor-cuts include a triangular piece of iris, of which the incision made by the knife forms the base, and which is then withdrawn from the eye by forceps. M. de Wecker introduces two narrower lance-knives at once, one on each side of the cornea, and from the centre of each incision makes two divergent scissor-cuts, so that the four may include a central and quadrilateral piece of iris, which, when extracted, will leave the pupillary space wholly free. In choosing between these methods the surgeon should be guided by the greater facility of access to the opaque deposit which may be offered by one or other of them in the particular case; and they may both be simplified by the use of a pair of fine scissors lately manufactured by Messrs. Weiss, and shown in Fig. 100, which, as they have one sharp point, render it unnecessary to penetrate the iris with the knife. The operations described are usually followed by loss of vitreous, and inflict a great shock upon the nutrition of an already enfeebled eye, so that they are seldom productive of very brilliant results; more especially as neither of them can be required unless the previous inflammation has been protracted and severe. A somewhat less formidable method, which may occasionally be adopted with advantage, is that of Dr. H. D. Noyes, of New York. He transfixes the eye with a linear knife, making both puncture and counter-puncture in the sclero-corneal junction, and thus obtaining an opening into the anterior chamber at each extremity of the horizontal diameter of the cornea. Before withdrawing the knife, he plunges its point through the centre of the combined capsule and false membrane, so as to make an opening there also. He next passes a blunt hook through each of the external

FIG. 100.

[1] [Both the operations described are due to Mr. Bowman.]

wounds, engages both the hooks in the central perforation, and tears this open, as far as may appear desirable, by pulling with one hook against the other, thus avoiding any dragging upon the ciliary region. The vitreous will generally project through the opening thus established, and will tend to prevent reunion of its edges. But the lesson to be learnt from all such devices, however successful they may be, is that the operator should strive to render them unnecessary. He should manage his iridectomy with such care, and should remove the cortex with such completeness, that no source of irritation shall be left behind; and he will then, generally speaking, be rewarded by uninterrupted healing and speedy restoration of sight.

The cases which present most difficulty are undoubtedly those in which it seems necessary, for any of the reasons already assigned, to extract a cataract which is not yet mature. In these, if, as sometimes happens, the pupil resists atropine, I perform the operation in the ordinary way, and in the most complete manner I can. But if the pupil can be fully dilated, so that it can be kept out of the way of a swollen lens, I generally puncture the anterior capsule with a needle, prior to any attempt at extraction. If no irritation is produced, the puncture may be repeated twice or thrice, at intervals of a few days, and in this way the cortex may be softened and rendered opaque by the action of the aqueous humor, so as to produce what may be called an artificial maturity; but extraction must always be performed immediately if any pain or pericorneal congestion should occur. In the preliminary punctures the needle must be used with great care and gentleness; since otherwise a hard nucleus might be dislocated into the vitreous body, and destructive inflammation lighted up.

In some cases of perfectly mature cataract in aged people, the capsule of the lens is stronger and more resisting than its attachment to the zonule of Zinn. When this is so, the lens and capsule may be removed together, with the capsule unbroken; and in cataracts of the kind referred to it is always worth while to make the external wound rather longer than usual, and, after the iridectomy, to see whether the lens and capsule cannot both be extruded by gentle pressure. If this can be done, the eye is left in the best possible state for rapid and perfect union of the incision. If the lens does not advance, the pressure must not be so increased as to rupture the zonule itself, and thus to occasion loss of vitreous. It is better, I think, to divide the capsule and proceed in the ordinary way. Professor Pagenstecher, by whom extraction within the capsule has been chiefly advocated, is accustomed, if the lenticular apparatus resists pressure, to remove it *en masse* by a spoon constructed for the purpose. There is seldom any difficulty in doing this, but the operation is apt to be followed by hyalitis, or at least by cell-proliferation and turbidity in the anterior portion of the vitreous; a condition which, although it generally clears up in course of time, may be fairly held to neutralize the special advantages which are claimed for the procedure.

CHAPTER XI.

GLAUCOMA.

The word Glaucoma, which was originally suggested by the greenish color of the pupil in some forms of the malady, and which was long used as a convenient general term to express ignorance rather than knowledge, has come, of late years, to possess a perfectly clear and definite meaning which stands in no kind of relation to its etymology. We now employ it to cover the whole series of morbid changes which are produced by increased fulness or tension within the eye; and we find it necessary to qualify it by adjectives expressive of different periods of duration, such as "chronic," "subacute," "acute," and "fulminating."

Concerning the causes which initiate increased tension within the eye we have neither positive knowledge nor even any very well-grounded conjecture. We can entertain no doubt that the secretion or formation of the aqueous and vitreous humors is in great measure governed by the nervous system; and we may reasonably believe that the diminution or disappearance of these humors is in great measure due to exhalation or exosmosis through the cornea and the sclerotic.[1] We know that transient or temporary increase of tension is a common accompaniment of the paroxysms of trifacial neuralgia; and we also see increase of tension (as already described) in serous iritis. Under both these conditions we may fairly assume, and in the latter we cannot doubt, the occurrence of actual hypersecretion. We know that glaucoma, save in a few exceptional cases, is seen only in patients who have passed the middle period of life; and we may infer that in them the processes of exhalation and exosmosis are checked by some involution or senile hardening of tissue. We have therefore two good working hypotheses: the first, that glaucoma may be caused by hypersecretion due to perverted nervous energy; the second, that it may be caused by impairment of function due to degeneration of tissue. Both these hypotheses may be true; and both will be found to harmonize with a great amount of clinical experience. They are in no way irreconcilable; and indeed it is manifest that the conditions to which they point may easily exist in combination, each of them intensifying the action of the other. At present, neither of them can be said to be proved; but they are certainly supported by high probability, and they afford a satisfactory basis for successful treatment.

Supposing a morbidly high degree of tension to exist, the con-

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[1] [See note to page 284.]

ditions of the ocular system of blood supply are eminently favorable to its continuance and its increase. The trunks of the venæ vorticosæ (vv. Fig. 1, page 19) pierce the sclerotic so obliquely that fluid pressure within the eye must necessarily compress and partially close their channels, and thus place an obstacle in the way of the outflow of their contents. The consequent fulness of the veins, by adding to the already excessive quantity of fluid in the chambers, would retard the entrance of arterial blood, and so both directly and indirectly, would impede the circulation, would check or even arrest nutrition, and would tend to the production of œdema. The arteries and veins of the retina bend into the optic nerve almost at right angles; so that these vessels, by increase of tension, are soon compressed against the margin of the sclerotic foramen in such a way as to reproduce, in the limited area of their closed circuit, the phenomena produced throughout the whole organ by the obstruction to the veins of the choroid.

Under the influence of such conditions, the fluid contents of the eyeball must constantly increase, and must exert a degree of pressure upon the ocular tunics, and upon the structures inclosed within them, of a kind which cannot fail to be highly prejudicial.

The effects upon the vascular system would be primarily to check the capillary circulation, both by the diminished force with which blood would flow through the arteries, and by the resistance offered by the contents of the veins. Secondarily to this, there would be distension of a number of smaller venous channels, through which the blood would endeavor to find an outlet. Of these the most conspicuous are the veins which pierce the sclerotic at a short distance from the cornea, and pass backwards under the conjunctiva towards the equator. In health, these veins, if visible, are never conspicuous, but in an early stage of glaucoma they become tortuous, and are distended by dark-colored blood to much more than their normal calibre.

Upon the nervous system of the eye the effects are more complicated. The optic nerve, at its entrance, constitutes the weakest and least resisting part of the globe; and, under the influence of fluid pressure, it is gradually forced backwards, until, from having been a prominence, it is converted into an excavation of variable depth. The layers of the retina become greatly compressed, and especially the nerve-fibre layer, as its elements bend round the edge of the sclerotic foramen, and from this, as well as from the imperfect supply of blood, a tendency to atrophy is produced, and vision becomes perceptibly impaired. The arrest of nutritive changes is probably most pronounced at the periphery of the retina; and hence vision first fails at the outer limits of the field. Contraction of the field of vision is often one of the most conspicuous symptoms of glaucoma, and in chronic cases the contraction creeps in towards the centre until sight is wholly lost. Both the sensory and motor filaments of the ciliary nerves are also squeezed as these nerves pass between the choroid and the sclerotic, so that the cornea becomes partially insensitive, and the movements of

the sphincter pupillæ and of the ciliary muscle are sluggishly and imperfectly performed.

The results above described are common to all cases of glaucoma, but the way in which they are manifested will depend, almost entirely, upon the rapidity with which the pressure is increased. We are familiar, in all organs, with a great tolerance of gradually increased pressure, and with an equal intolerance of that which is produced suddenly. In the eye this difference is very manifest; for, while chronic glaucoma is liable to be mistaken for atrophy, acute glaucoma is liable to be mistaken for inflammation. I will try to sketch types of the four principal varieties of the disease, premising only that they fade into each other by imperceptible gradations.

In purely chronic glaucoma, the pressure increases so slowly that it may destroy the functional activity of the retina before it produces any conspicuous vascular change. The patient, who is commonly past the middle period of life, becomes conscious that his customary reading spectacles no longer afford him sufficient help, and he perhaps buys a stronger pair. After a short time these also fail of their effect, and he again has recourse to the optician. This course of events may be repeated more than once, but at last the patient becomes convinced that his "sight is failing," and he seeks professional counsel. By this time the vision will be distinctly subnormal, both for distant and near objects; and, even after the correction of a degree of presbyopia in excess of that natural to the period of life, "brilliant" type can scarcely ever be read, or can only be read with difficulty. At this period it is often found, in persons not previously myopic, that a weak concave glass will somewhat improve distant vision; a certain amount of myopia having been produced by the elongation of the antero-posterior axis of the globe, occasioned by its general distension, or perhaps, in some cases, by the pushing forwards of the crystalline lens by the excess of fluid in the vitreous chamber. The extent of the field of vision will also be diminished, generally in a somewhat greater degree on the nasal than on the temporal side. If the acuteness is recorded, and the field mapped out, it will mostly be found that a period of two or three weeks will produce a change for the worse in both these respects. The appearance of the eyes may be unaltered, but the pupils will be somewhat large, and sluggish to contract; and the anterior choroidal [ciliary] veins, which emerge from the sclerotic not far from the cornea, will generally be very visible. A light finger-touch upon the cornea is less productive of reflex contraction of the orbicularis than it would be in a healthy eye; and the globe is perceptibly hard on palpation. If both eyes are affected, as will often happen, they are usually affected in different degrees; and there can be little doubt about the diagnosis if the worse eye of the two is also the harder. The media are usually quite transparent, and the ophthalmoscope reveals very characteristic conditions. The first inspection with the inverted image shows a

somewhat pallid nerve-disk, on which the veins are, as a rule, distinctly larger and darker than the arteries, which, by contrast if not absolutely, are pale and small. The pallid disk is surrounded or partly bordered by a fine white line, the edge of the sclerotic foramen, rendered conspicuous by the compression, wasting, and increased translucency of the nervous tissue which usually somewhat conceals it from view. If slight pressure be made upon the globe, through the medium of the upper lid, by the tip of a finger, the disk will be seen to become more and less pallid alternately, at intervals synchronous with the radial pulse; or sometimes these alternations are seen without pressure. The erect image shows that they are caused by the blood in the veins being driven back from the centre of the disk towards or beyond its periphery; this happening at the acme of the pulse-wave, and being a distinct pushing back of the venous blood to make way for the entrance of the arterial.[1] As the blood recedes in the veins, their walls collapse, and so much color upon the disk is momentarily lost, to be restored as the venous currents reassert themselves between the pulse-waves, and again distend the veins. The same method of examination shows that the surface of the optic disk is more or less uniformly concave, or converted into a sort of saucer-like excavation; over most of which the lamina cribrosa is unnaturally visible, being revealed in the same way as the edge of the sclerotic ring. These conditions were originally described as "atrophy with excavation of the optic nerve;" and if the pressure goes on increasing in the same gradual manner, the sight slowly and painlessly fades away.

In the subacute form of glaucoma the characteristic feature is that the increase of tension does not take place uniformly and gradually, but by a succession of attacks, each one of which is sufficiently pronounced to affect vision injuriously at the time, but each of which is followed by a distinct remission and improvement. An attack shows itself as a sudden clouding over of the sight, a sense of greater or less darkness, which may vary from a mere passing obscuration to a temporary extinction of vision. The cloud is generally attended by pain in the eyeball, sometimes of a severe character. After a short period the vision returns; but never quite to the degree of acuteness which existed before the attack. It is difficult to say whether the remissions are due to relief of tension by some natural compensation, as by increase of room gained at the expense of the optic nerve, or to the eye becoming accustomed to that which was at first unendurable, or to both these conditions. Between the attacks, it may not at first be easy to discover anything amiss; although there would always be defective accommodation, and some degree of abnormal hardness. But after the attacks have been several times repeated, and especially if they have followed each other at short intervals

[1] [For a presentation of the generally accepted theory of venous pulsation in the optic disk, see page 110.]

of time, the glaucomatous state becomes fairly established. There is high tension, contraction of the field, and subnormal acuteness of vision. A common, but not a universal symptom, is the appearance of rings of color around the flames of lamps or candles. The vascular system of the eye is more disturbed than in the chronic form; the anterior choroidal veins are more conspicuous, and the ocular conjunctiva is passively congested. The pupil is somewhat dilated, often assuming the form of an ellipse with its long axis horizontal; and the iris is often pushed forwards towards the cornea, so that the depth of the anterior chamber is diminished. The ophthalmoscope shows spontaneous or readily excited venous pulse, and also an excavated disk; but the excavation differs from that of the chronic form as a pit differs from a saucer. Instead of presenting a concave surface, it is a hollow with perpendicular sides and an approximately level floor. It is bounded by the edge of the sclerotic ring, and it is recognized by the fact that the vessels bend round this ring at right angles, disappear for a space, and then reappear, after another rectangular bend, on the floor of the pit, where they are seen as if somewhat laterally displaced from the retinal portions with which they are really continuous. Where they bend round the sclerotic ring they are often distended, the elbow permitting a local accumulation of blood; and if the pit is deep the retinal portions may appear to terminate as hooklets, just passing over its margin. The greater distance of the deeper portions from the observer can be readily demonstrated; with the erect image, because they cannot be clearly focussed together with the retinal portions, and often not without a concave lens behind the mirror; with the inverted image, because the apparent parallactic or to-and-fro movement of the margin of the pit, in response to lateral to-and-fro movements of the object lens, is different from that of the floor, so that the pit does not appear to move together, as a whole, but its margin and floor appear to move to a different extent, or even in opposite directions. It has already been mentioned that the pit is bounded by the sclerotic ring; and by this character it may be distinguished from every form of congenital or physiological excavation, in which there is always a circle of nerve-tissue between the sclerotic and the edge of the depression.

The chief characteristic of acute glaucoma is the absence of remission. The disease commences with pain and obscuration of sight; the obscuration never clears up, and the pain never ceases. The symptoms may vary a little in intensity from time to time, but the general progress of events is from bad to worse. The stretching of the ocular tunics produces something which resembles inflammatory reaction, and the conjunctival vessels are usually much congested. Hæmorrhages sometimes occur in the retina or choroid; and the nutrition of the cornea suffers, its external epithelium being disturbed, and its surface looking like glass which has been breathed upon, so that ophthalmoscopic examination may be wholly prevented. The vision is early and greatly

impaired, soon sinking to mere perception of light or of large objects, and soon afterwards being extinguished altogether. The "fulminating" form differs from the acute only in the extreme degree of tension, the agonizing character of the pain, and the loss of sight in the course of a few hours instead of in the course of days or weeks.

On comparing the phenomena which have thus been briefly described, it is manifest that they do not differ in their essential nature, but only in the degree and rate of increase of the tension. Moreover, the chronic form of glaucoma is apt to lapse into the subacu e; and the subacute is apt to lose its remissions and to become acute, before the natural termination of the malady is reached. This termination is, in the first instance, blindness; and, after blindness, it occasionally happens that the cornea may give way and the eyeball collapse. Sometimes the blind eye continues to be acutely painful; but more frequently the glaucomatous process arrests itself, and stops hypersecretion by its very interference with blood-supply and with nutrition. Pain subsides, and tension no longer increases. The eye is left of stony hardness, is insensible to light, and is traversed, in and beneath the conjunctiva, by numerous tortuous and dilated veins. The pupil is dilated and fixed, the iris discolored and pushed forward. The derangement of nutrition often produces cataract; and the whole condition is described as "Glaucoma consummatum."

Against glaucoma in all its forms, and from their commencement to their termination, the resources of the Pharmacopœia are utterly useless. They are even worse than useless, for their employment wastes time and loses opportunity. The only remedy for the disease is the operation of iridectomy. Before 1856, glaucoma was justly regarded as being beyond the reach of any treatment then practiced; but the ophthalmoscope, by showing the excavation of the optic disk, caused the increase of tension to be more regarded than it had been prior to this discovery. Von Graefe, who had observed that the excision of a large piece of iris, in making an artificial pupil, was always followed by marked diminution of tension, determined to try how the same proceeding would affect glaucomatous hardness; and his experimental operations soon convinced him how brilliant was the success which he was destined to achieve. Surgery has won few greater triumphs than the inclusion of the whole glaucomatous class among the maladies which admit of cure by means of operation.

The *rationale* of the relief to tension afforded by iridectomy has been much discussed, but is not even yet a subject upon which entire agreement has been reached. It is obvious that the incision, by permitting the escape of the aqueous humor, must both soften the eyeball and liberate its circulation; but this does not explain the matter, because after a mere paracentesis the tension reasserts itself with great rapidity. The permanent effect is probably due to three elements,—first, to the diminution of the secreting surface of the iris; secondly, to the removal of so considerable a portion

of the solid contents of the eyeball; thirdly, to the establishment of a line of comparatively permeable cicatrix, through which exhalation or exosmosis may take place freely, in the previously dense and rigid sclerotic.[1] Whatever may be the explanation, the fact remains. Tension is actually diminished by iridectomy, and is diminished almost in proportion to the size of the piece removed, and to the completeness with which certain precautions are observed during the operation.

The curative power of the relief of tension is not unlimited. In every case of progressive glaucoma, at any given period, the existing impairment of sight is made up of three elements. There is the absolute destruction or disorganization of retinal tissue, either by pressure or by arrest of capillary circulation, which is completed, and is irremediable. There is the temporary suppression of function, due to pressure and congestion, which ceases as soon as the pressure is removed and the congestion relieved. There is an intermediate state, something beyond the latter, but not so much advanced as the former, affecting parts of nerve-tissue which do not at once respond to an operation, but which are capable of gradual repair. The first element preponderates in the chronic cases, the second and third preponderate in the acute The third is common to all, but is insignificant in extreme chronicity or extreme acuteness. In a chronic case, the operation will sometimes prove to be altogether fruitless, the atrophy continuing its progress notwithstanding the relief of tension; but, as a rule, the surgeon may hope to arrest the decay of sight at the actual point which it has reached, and generally to obtain, in the course of three or four months, some degree of improvement. In a subacute case, as long as the patient can count fingers, or can discern large objects, the surgeon may expect much immediate improvement, which for a time will slowly increase. In an acute or fulminating case, as long as there is perception of light, he may expect the early restoration of almost normal vision.

Besides the types above described, there are certain irregular forms of glaucoma in which the diagnosis may be difficu't. In some cases the posterior hemisphere of the eye may yield to the pressure and become somewhat elongated; thus masking increased tension by giving increased space, and at the same time producing a progressive myopia. Quite lately I have seen a patient with double conical cornea which had been for many years stationary, but in whom the projection suddenly increased in the left eye, and its summit became turbid from disturbance of the epithelium. The turbidity, at first sight, seemed sufficient to explain the fresh impairment of vision; but a careful investigation gave proof that the increased projection and the turbidity were themselves the results of suddenly heightened tension. In this instance the pa-

[1] [The suggestion of Donders, that glaucoma may be a reflex neurosis of the secretory nerves of the eye, originating in or dependent upon irritation of the nerves of the iris, seems worthier of consideration than either of the suggestions offered in the text.]

tient was somewhat advanced in life; but cases of still greater obscurity present themselves in comparatively young subjects. Some years ago I was consulted by a druggist's assistant, aged twenty, whose history was that in making a strong muscular effort the sight of his left eye became obscured. The obscuration rapidly increased, and he said that for a time he lost perception of light; but when I saw him, five hours after the commencement of the attack, the perception had returned in the qualitative degree. His pupil was widely dilated and circular, the globe tense, the veins of the disk pulsating, the arteries contracted. I made a large iridectomy without delay; and when the lids were opened twenty-four hours afterwards vision appeared to be fully restored. A more accurate testing, when the cicatrix had become firm, showed that the distension had produced myopia $= \frac{1}{20}$, which has remained unchanged. A few months ago a man thirty-eight years old, a house painter, applied at the Royal South London Ophthalmic Hospital, complaining of short sight, which had come on within a recent time, and was a serious hindrance to him in his business. The degree of myopia was determined in the usual way with concave lenses, was noted on his paper, and he was told to come again in a week. At the end of a week he returned as directed; and it was found that he then required glasses of considerably greater power than those first set down. An ophthalmoscopic examination discovered excavation of both optic disks, going quite up to the sclerotic margin, and so deep that, in the right eye, while a concave lens of $\frac{1}{24}$ gave a clear erect image of the margin, a lens of $\frac{1}{8}$ was required in order to do the same for the floor of the cup. When the myopia was corrected, the acuteness of vision was normal or nearly so; but there was manifest high tension, notwithstanding the space gained by the excavation of the disk and by the yielding of the ocular tunics. The patient refused to undergo an operation, although forewarned of the probable consequences, and he ceased attendance for a time. In a few weeks he returned, saying that the sight of the right eye was much worse, and that he would submit to whatever was thought advisable. There was but a small increase in the myopia; and little or no change in the excavation; but the acuteness of vision had sensibly diminished. I performed an iridectomy on this eye, with the unusual result that the incision did not heal for some weeks, the rest of the iris remaining in contact with the cornea, and the aqueous humor leaking away as fast as it was secreted. At the same time the patient suffered intense pain from intermittent neuralgia of the first division of the fifth; and this combination of events induced me to ascribe the whole series of morbid phenomena, the high tension, the extensibility of the ocular tunics, the delayed healing, and the pain, to some original perversion of nervous action. The eye was very carefully bandaged, and the neuralgia was kept in check by small doses of quinine frequently administered. At length union took place, the pain abated, and the conjunctival injection began to subside. I deferred any employment of the ophthalmoscope, or

any determination of the state of vision and refraction, until the consolidation of the cicatrix was completed; but before this time arrived the patient again absented himself for a considerable period. When at last he came, I found continuing excavation and unnatural pallor of the optic disk; but the anterior chamber was restored, the glaucomatous process was arrested, and vision remained in the same state as immediately before the iridectomy. He expressed his readiness to undergo an operation on the left eye also; but in this the symptoms were not urgent, and I advised delay for a time, in order that we might watch the course of events.

Notwithstanding the doubtful or even the unfortunate issue of individual cases, there can never be any question with regard to the course which should be pursued in every instance in which intraocular hypersecretion is discovered. It matters little whether high tension declares itself to the touch, or is partly concealed for a time by the yielding of the disk or of the sclerotic. Such yielding is in itself highly prejudicial, and must of necessity soon reach its limit. As soon as a state exists which can be called glaucomatous, iridectomy should be performed without unnecessary delay; and even when vision is lost the operation will afford the best means, short of enucleation, of relieving pain. In acute glaucoma we must no longer measure the available time by days, but by hours; and in the "fulminating" form the delay even of an hour may be fatal to all hope of the restoration of sight.

Glaucoma resembles cataract in usually attacking both eyes, but one sooner than the other. There is a curious concurrence of testimony in support of the belief that an iridectomy of the eye which first suffers, however successful, tends to hasten the outbreak of the disease in its fellow. I have heard a patient say that the operation "had only driven the complaint out of one eye into the other;" and it is generally desirable not only to give explicit warning of this probability, but also to operate on the second eye early, without waiting for more than premonitory signs. It should also be noted that glaucoma may be combined with incipient or even with mature cataract; and the surgeon must be on his guard not hastily to accept striation or opacity of the crystalline lens as a sufficient cause for glaucomatous impairment of sight. The subjective symptoms in the two cases are so entirely different that no error ought to be possible. Cataract does not produce pain, does not produce any diminution of the extent of the visual field, and does not produce temporary or fleeting obscurations of sight. Objectively, it may interfere with ophthalmoscopic examination; but it is not attended by dilatation of the pupil, by either active or passive congestion, or by any increase in tension. If these differences are borne in mind, the presence of cataract will never lead an observer of ordinary carefulness to overlook the presence of glaucoma.

In order to perform the operation of iridectomy, the surgeon should be provided with a spring speculum for separating the

eyelids, a fixation hook or forceps, a lance-shaped or linear knife, iris forceps and scissors, a blunt probe or spatula, some lint, cotton-wool, and a bandage. It is quite possible to operate without an anæsthetic; but to do so, as already stated in the previous observations upon this subject, entails increased and unnecessary risk. Restlessness, and spasm of the ocular muscles, are serious sources of danger; and may occasion either injury to the crystalline lens, or hæmorrhage from some over-distended vessel which is suddenly deprived of the support previously given to it by the intraocular pressure. Unless there is some very cogent objection, complete anæsthesia should be regarded as an essential preliminary.

When iridectomy is intended to furnish an artificial pupil, the situation chosen must be that in which the pupil will be most useful; but when it is performed for the relief of tension, the middle third of the upper half of the iris is the part which should usually be removed. The resulting gap will be partly covered by the upper lid, and will therefore be at once less unsightly and less disturbing to vision than it would be in any other portion of the circle.

The choice of a knife must depend upon the depth of the anterior chamber; that is to say, upon the position of the lens and iris. If the chamber is of natural depth, and the plane of the iris vertical or nearly so, a lance-shaped blade may be taken. If the iris is driven forwards, so that the lance-knife would endanger the lens in traversing the area of the pupil, then a linear knife is necessary. Anæsthesia being complete, the patient suitably placed, and the speculum inserted, the surgeon makes his fixation close to the corneal margin, opposite to the centre of his intended incision. If necessary, he slightly rotates the globe, imitating the action of the corresponding rectus muscle, but never lifts or pulls it, and simply holds it still, without pressure, when the desired position is attained. If the lance-knife has been selected, its point is placed on the conjunctiva, a little behind the corneal margin, in the centre of the intended incision, and is made to pierce the sclerotic and to enter the anterior chamber immediately in front of the iris, by a steady gentle thrust directed towards the centre of the eyeball. As soon as the point of the knife can be seen through the cornea, its direction is changed, the handle being sloped backwards so as to direct the point forwards; and in this position it is pushed steadily on, the operator watching the opposite margin of the pupil to see that the point rides safely over it. Supposing the aqueous humor to be retained, and the operation to be undertaken for the relief of tension, the thrust is continued until the parallel-sided part of the blade is fairly within the chamber, or, with an angular knife, until the external incision attains a length of six or eight millimetres, which will correspond to four or six millimetres of internal wound. The knife is then very gently and quietly withdrawn, so as to allow a gradual escape of the aqueous humor. If the knife is too narrow to make a wound of the desired length, the external angle may be enlarged by cutting with

the side of the blade as it is withdrawn. If the aqueous humor should escape prematurely, before an incision of sufficient length has been made, the forward thrust must be immediately checked and the blade withdrawn, in this instance again cutting laterally during its exit. If a linear knife is used, its point must be placed at one extremity of the intended incision, and introduced into the anterior chamber nearly as far as the margin of the pupil, over which it must not pass for fear of wounding the lens. It may then either be brought up, so as first to effect a counter-puncture at the other extremity of the incision, and then to divide the bridge of intervening tissue as in cataract extraction, or [following the plan suggested by Mr. Streatfeild] it may be made to cut its way along, just outside the corneal margin, to the required extent, or until the escape of aqueous humor renders the presence of a sharp-pointed instrument in the anterior chamber dangerous. The blade being withdrawn, the surgeon should next satisfy himself that his incision, however made, is long enough for its purpose; and, if necessary, he may extend it a little at one or both of its extremities, either by scissors or by any small knife which has a blunt extremity and a cutting edge. In all cases of glaucoma it is of importance to remove a sufficiently broad piece of iris, and to remove it in its entire width, tearing it from its ciliary attachment. For these purposes it is necessary to have a wound of adequate length, placed a little outside the cornea. In endeavoring to fulfil these conditions an inexpert or careless operator may enter the globe behind the iris, may wound the iris at his first puncture, may divide the capsule of the lens, or may entangle the point of his knife in the opposite pupillary margin. All these, however, are accidents which ought never to occur.

The section being satisfactorily completed, the eye may be freed from tears and blood by a morsel of moistened sponge, or by a strip of soft rag. If the muscles are quiet, and if the cornea occupies a central position in the palpebral opening, no fixation will be needed; but if the eye is so placed that the wound is not easily accessible, an assistant must gently apply the hook or forceps to rectify the malposition. If the iris has prolapsed, the surgeon has only to take hold of it and to perform the necessary excision.[1] If it has not prolapsed, the closed iris forceps must be passed into the anterior chamber, nearly to the margin of the pupil, and there suffered to expand to an extent proportionate to the size of the piece to be removed. They are then closed upon the iris as it rises between them, and the plait which is seized is drawn gently out of the eye. If the object is only to cut a notch to serve as an artificial pupil, the first incision through the external tunic may be small, and the scissor blades may be placed as close behind the forceps as possible, so that only the piece actually held by the latter may be taken out, and the rest suffered or coaxed to return into

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[1] [To incise the corneal margin in this latter way it is better to use the triangular cataract knife of Beer (Fig. 46, page 157), as directed by Mr Streatfeild.]

the anterior chamber. If the object is to relieve tension, the operator cuts in a different direction, close to or even within one extremity of the wound, and quite up to the ciliary margin of the iris. He then tears the piece still held by the forceps from its attachment, as far as the other extremity of the wound, holds it somewhat upon the stretch, and excises it within the lips of the wound as before. If any portion of iris remains entangled at either extremity an attempt may be made to seize and snip it out, or it may be gently replaced by a small spatula, or caused to return by carefully managed friction. If it should resist these measures it may be left alone, and dealt with on a future occasion. The speculum should be removed, and coagula between the edges of the incision carefully picked out by the iris forceps, and blood in the conjunctival sac taken away by the point of a bit of sponge. A compressive bandage must then be applied in the ordinary way, and the patient sent to bed. By the third day, or sooner, the wound will usually be healed and the aqueous humor retained; but the blood poured out by the cut vessels of the iris may require a longer time for its absorption, and may keep up some degree of irritation until it is absorbed. During this period atropine should be applied, the day spent in a dimly lighted room, the eyes kept entirely at rest, and the compressive bandage worn at night, or during recumbency in the daytime. As soon as the blood has disappeared and the irritation is diminishing, the patient may be suffered to go into the air in favorable weather. Any piece of iris incarcerated at either extremity of the cicatrix may be treated as described in the chapter on cataract, either by puncture and slight cauterization, or by being severed, by the thrust of a cutting needle, from the intraocular portion with which it is continuous.

After the performance of an iridectomy, a recurrence of glaucoma will sometimes be met with. If the iridectomy had in any way been imperfectly accomplished, a second one should be done adjoining the first. If the iridectomy had been perfectly accomplished, the second should be opposite the first, so as to form what has been called a diametral pupil. It will generally be found that this procedure will finally overcome a tendency to increase of tension; but it will often fail to arrest the decay of sight, and it will be followed in some instances, by wasting of the eyeball.

CHAPTER XII.

DISEASES OF THE FUNDUS OCULI.

When impairment of vision cannot be accounted for by manifest changes in the superficial portions of the eye, the cause of the defect may often be discovered by ophthalmoscopic examination. The transparency of the media should first be ascertained by the mirror alone, and the inverted image should be employed in order to obtain a general view of the fundus. This having been sufficiently studied, the erect image may be used for the more exact investigation of the state of particular portions of the field.

On account of its conspicuous appearance, and also because it forms a convenient point of departure, the entrance of the optic nerve is usually the part first looked at in an ophthalmoscopic examination. Besides excavation, which has been mentioned in the preceding chapter, the chief morbid changes seen in the nerve entrance itself are swelling and atrophy; but the former, in its earlier stages, is only seldom brought under the notice of the ophthalmic surgeon. In the first chapter, on Anatomy and Physiology, mention has been made of the space, continuous with the sac of the arachnoid, which exists between the two sheaths of the optic nerve;[1] and which terminates abruptly at the level of the lamina cribrosa. It seems to be ascertained that many conditions of intracranial disturbance, such as meningitis, simple dropsy, or the growth of tumors, which are alike in being attended by an increase of the contents of the skull, may drive the subarachnoid fluid into this intervaginal space, sometimes with sufficient force to distend the external sheath into a considerable bulbous enlargement. Distension of the intervaginal space is attended, of course, by compression of the nerve-trunk immediately behind the eye; and this compression, in its turn, diminishes or closes the channel of the retinal veins, and impedes or prevents the natural outflow of the blood which is contained in them. Hence may arise simple œdema of the disk, causing increased projection of its surface, obscuration of its boundaries, partial or entire concealment of the vessels by which it is traversed, and, sometimes, patches of capillary hæmorrhage. These conditions may extend themselves more

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[1] [The anatomical division of the sheath of the optic nerve into three layers continuous, respectively, with the dura mater, arachnoid, and pia mater, necessitates the division of the intervaginal space so called, into two spaces, viz.: a subdural space continuous with the arachnoidal cavity of the cranium, and a subarachnoidal space continuous with the subarachnoidal cavity; see page 32.]

or less over the retinal surface, producing swelling and turbidity of the membrane itself, with distension and varicosity of its veins. They are doubtless succeeded, in many cases, by secondary inflammatory changes due to the alterations in the circulation and to the local disturbance, changes analogous, in some degree, to the erythema which so often supervenes on dropsy of the legs; and they are said to be sometimes complicated by direct inflammation, creeping down the nerve-sheath from the pia mater. Hence the appearances may vary within rather wide limits as regards the amount of swelling, its color or opacity, and the degree in which it buries and conceals the vessels and the disk boundaries. I must confess that I have never been able to satisfy myself of the value of any opthalmoscopic sign as showing the presence of inflammation, or the predominance of inflammatory over obstructive changes; and I greatly doubt whether the many elaborate descriptions of the appearances, which have from time to time been written, have as yet brought us very near to any trustworthy differential diagnosis between the several conditions which may exist either singly or in combination. On this account I greatly prefer the term "choked disk," which has been suggested by Dr. Clifford Allbutt, to such a word as "neuritis;" the former being simply descriptive, while the latter commits those who use it to a possibly mistaken judgment about the facts. It is not material whether the "choking" is a result of œdema only, or of œdema complicated by inflammation; whether the swelling is simply passive, or is produced or increased by cell-proliferation or tissue hypertrophy. The expression "choked disk" will include all these conditions; but the word "ischæmia," which Dr. Allbutt proposes as an equivalent for it, seems to me to be objectionable, even if only on the ground that it had been previously applied, by Professor Alfred Graefe, to denote an entirely different condition.

The most remarkable peculiarity connected with swelling of the disk is that it may exist, in a very pronounced degree, without any impairment of sight. The explanation of this is, in all probability, that the changes may for a long time be limited to the fibre layer of the retina, which is not continued over the yellow spot; that the nutrition of the bacillary layer is dependent upon the capillaries of the choroid; and that the conducting nerve-filaments are unaffected by a degree of pressure which is sufficient to obstruct the veins. The announcement of the frequent coexistence of great nerve swelling with normal vision was received, when first made, with something like incredulity; but the fact has long been familiar to those who, following the example set by Dr. Hughlings Jackson, Dr. Clifford Allbutt, and Dr. Buzzard, have systematically practiced ophthalmoscopic examination in all cases of suspected intracranial disease. The researches of the above-mentioned physicians have shown, beyond question, that great swelling of the optic disk may occur and may be recovered from, so that nearly all trace of its existence may disappear, without there being at any time the smallest indication, other than the

ophthalmoscopic evidence, of the participation of the eyes in the effects of some obvious malady. The same observers have shown, also, that a choked disk without impairment of sight may, nevertheless, be the precursor of atrophy terminating in blindness; and we can now entertain no doubt that most of the cases of atrophy which come before the ophthalmic surgeon only when failure of vision is declared, and when tissue degeneration is already far advanced, are really consecutive to swelling of the disks which was not discovered at the time of its occurrence. This is probably the ordinary explanation of the blindness or impairment of sight which sometimes follows typhoid or scarlet fever in which "head symptoms" have been prominent. It is obvious that the suggested pathology of the affection will also readily explain why in some instances sight becomes affected even during the period of swelling and infiltration; for there must be a point beyond which obstruction of the veins would interfere with the nutrition of the conducting filaments, and beyond which compression of the nerve-trunk would arrest the propagation of impressions I do not know that we have any indication when these poin's have been passed, except from the statements of the patient; or that the ophthalmoscope, in any case of swollen disk in a delirious or unconscious subject, would enable us to say anything certain with regard to the actual state or the probable future of the visual function. Many attempts have been made by various writers to distinguish "neuritis optici" from "perineuritis," and both from mere mechanical obstruction; but I have never been able to satisfy myself of the validity of the distinctions which have been drawn. Dr. Hughlings Jackson, who has investigated the subject with infinite pains and care, and who has followed a large number of his cases to the post-mortem table, will not say more than that "optic neuritis," his general expression for the changes under consideration, is an evidence of some coarse intracranial lesion; and I myself can only say that it is frequently associated with such lesion. We had a little boy in St. George's Hospital, in 1872, who was transferred from my care to that of Dr. Fuller, and who had choked disks of the most typical character. Dr. Hughlings Jackson saw him, and entertained no doubt that he was the subject of some form of brain disease; and the same opinion was expressed by Dr. Noyes of New York, and by several of the members of the International Ophthalmological Congress, which was then assembled in London. The boy died of pleurisy supervening upon advanced kidney disease, and no trace of mischief in his brain could be discovered by the most careful examination. Nearly at the same time we had in the hospital a young woman, whose eyes presented typical examples of the changes often associated with albuminuria, but who died, with healthy kidneys, of a tumor in the cerebellum. My own impression is that great differences in the aspect of a swollen disk may be produced by conditions unconnected with the primary disease; as by differences in the number and the manner of distribution of bloodvessels, in the quantity and quality of the con-

nective tissue, in the tenuity of the coats of veins, and in the natural or acquired liability of the individual to inflammatory change. The tendency to the relief of vascular distension by hæmorrhage would probably exist in an inverse ratio to the tendency to the relief of distension by transudation of serum. The amount and shape of swelling would be largely governed by the comparative laxity or rigidity of the connective tissue. The stretching and local perturbation which would provoke inflammatory action in one person would fail to do so in another. Proceeding from probabilities to experience, I may say that I have seen almost all possible types of swelled disk, either in my own practice or in the patients in the medical wards of St. George's Hospital; and that I have never been able positively to connect any one of these types with any de nite condition. I say this with much regret; for nothing could be more agreeable to me than to enlarge the usefulness of the ophthalmoscope as a means of diagnosis. I must add that I have over and over again watched the optic disks, from day to day, in cases of tubercular meningitis. I have seen them become choked, and I have seen them escape entirely; but I have never seen choking occur sufficiently early to be useful in establishing a diagnosis which would otherwise have been uncertain.

Taken alone, therefore, swelling of the nerve-disks cannot be regarded as a substantive malady. It is never more than a condition the true meaning of which must be inferred from other signs; and it may be looked upon most hopefully when it occurs in a syphilitic subject. It is then probably due to intracranial gumma, which may be amenable to treatment by mercury or by iodide of potassium. In cases in which swollen disk is associated with head symptoms of a grave character, such as intense headache, delirium, or stupor, M. de Wecker has suggested the advisability of tapping the sac of the arachnoid by means of an incision through the outer sheath of the optic nerve; and he has related an instance in which he put this plan into execution without any ill-consequence, the state of the patient being such that improvement was hardly to be expected. He made an incision through the conjunctiva between the external and inferior recti muscles, and carried an index finger along the globe, which he luxated somewhat upwards and inwards, until he touched the distended nerve-sheath. The finger then served as a guide for a small guarded bistoury, by which a longitudinal incision was made through the sheath, quite up to its termination in the sclerotic. The operation would not be difficult of performance, and I can imagine conditions in which it might not only be justifiable, but possibly even curative. I should not hesitate to attempt it in case of need; but have not yet met with an instance in which it appeared to be called for.

From swelling of the disk to atrophy, the transition is manifest and easy; but the atrophy appears to occur under two different conditions,—either simply as a result of irrecoverable disturbance

of nutrition, or as a result of the contraction of effused material. It is quite possible that these conditions may coexist; and it may not always be practicable to determine which of them is predominant. In well-marked examples of the former kind we see a disappearance of nerve-tissue, which brings into prominence the circle of the sclerotic foramen and the mottling of the lamina cribrosa; and in well-marked examples of the latter we see merely an almost uniform whiteness of the disk, without depression of its surface. In both, the arteries dwindle, sometimes to mere threads; and the condition of the veins will depend very much upon antecedent events. When the swelling of the nerve has been considerable, and the obstruction of the venous channels almost complete, the veins never return to their original directness of course. Notwithstanding the subsidence of the swelling, they remain elevated in bold curves, comparable to arches, as they pass over the margin of the disk; and their continuations upon the retina are either beaded by varicose dilatations or bent into serpentine tortuosities. Such appearances, in any case of atrophy, even if they are slight in amount and limited to a single vessel, point to antecedent swelling, with, I believe, absolute certainty; and also, by their degree, afford a measure by which the amount of such past swelling, and of the obstruction connected with it, may be at least approximately estimated. When the veins pass straight over the disk margin, and follow a natural course upon the retina, it is a fair inference that they have neither been obstructed nor disturbed.

Some years ago, when atrophy of the optic nerves was regarded as a substantive malady, Von Graefe and others bestowed infinite pains upon the study of the subjective symptoms which may attend upon it; and endeavored to deduce from these symptoms conclusions which might assist in diagnosis, prognosis, and treatment. They carefully mapped the extent of the failing vision, and attached importance to ascertaining whether the failure was concentric or in sectors. The discovery that swelling which does not affect the sight is yet an ordinary precursor of atrophy which destroys it, has taken away, at all events in a great degree, the necessity for attending to such distinctions. It is conceivable that the shape and position of the most defective parts of the retina may be associated with the seat of an intracranial lesion; but it is manifest that accidental local conditions in the disk itself, the disruption of connective tissue, or the effusion of lymph in this part of it or in that, would be sufficient to produce a great variety of different localizations of visual defect. Three or four years ago a little boy was brought to the South London Ophthalmic Hospital with a history that he had fallen from the roof of an outhouse, and had since lost the sight of his left eye. I found the left eyeball much projected from the orbit, all perception of light lost, and the disk greatly swollen. The right eye was wholly unaffected, but there was much headache and nocturnal restlessness. I regarded the case as one of extravasation of blood within the orbit; and the swollen disk as being due to the compression

of the nerve, and to its being stretched by the protrusion of th globe. Iodide and bromide of potassium were given, with chlora hydrate at night. The pain and restlessness were soon relievec and in the course of a short time the eyeball returned to its prope position; but the swelling of the disk passed into atrophy of tha uniform whiteness which I take to indicate the presence of adver titious deposit. The boy would not acknowledge any perceptio of light whatever; and about four months after his fall I tool him one evening to St. George's Hospital, and exhibited his lef optic disk to a large number of students with a demonstratin ophthalmoscope. Regarding his eye almost as if it had been a artificial one, I kept it in the full glare of the instrument as lon as anybody wished to see it, certainly for more than an hour. can only suppose that this powerful stimulation roused some c the nerve elements of the retina from a dormant state; for two o three days afterwards, when the boy next presented himself at th South London Hospital, his first words were, "Please, sir, I can se a little." On examination, it was found that he could distinguis colors, count fingers, and decipher very large letters, over a limite space in the lower and outer quadrant of the field of vision; tha is to say, with a small portion of the upper and inner quadrant o the retina. I determined at the time that I would expose him t light again; but he was very soon afterwards attacked by diseas of the vertebral column, and he has since been in so crippled an precarious a state that it has not been practicable to carry out m intention. The vision has remained unaltered; and the specia interest of the case seems to be that in swelling and subsequen atrophy due to an extracranial cause, which chanced to imitat the action of some of the ordinary intracranial causes, we had localization of the visual defect which can only be explained b supposing that the conducting filaments from a certain retinal re gion had in some way eluded the compression to which all other were subjected in or near the sclerotic foramen. If we once admi that localization of defect may be due to conditions existing in th disk itself, we deprive such localization of all value as a sympton of intracranial disturbance.

Notwithstanding the example and the writings of the distin guished physicians to whom I have referred, it must be concedec that the great majority of medical practitioners do not make us of the ophthalmoscope in all cases which are attended by head symptoms; and hence there can be no doubt that a very larg amount of swelling of the optic disks remains undetected until i has passed into the stage of commencing atrophy, and until th patient becomes conscious of progressive impairment of sight This consciousness will arise sooner in some persons than in others and will excite some to more speedy action than others; whenc it happens that ophthalmic surgeons see atrophy for the first tim in various stages of progress, and blended with various degrees o residual hyperæmia. We read of cases in which one sector of th disk is said to be white, while the rest of the circle is congested

but all such descriptions must be received with a good deal of caution. In the first place, the apparent color of the disk is greatly influenced by the color and the intensity of the light thrown upon it. In the next place, if there is really a white sector, it might easily cause the rest of the surface to appear congested by contrast; it being remembered that the normal disk is very distinctly tinted by its capillary circulation. We read of cases in which atrophy was preceded by general inflammatory redness of the nerve-tissue—true neuritis, or red softening. I do not deny that such cases may exist; I only say that either I have never met with them or that I have failed to recognize them. When I see a combination of partial atrophy with partial hyperæmia, I am accustomed to see also that arching of the veins over the disk margin, and that sinuosity of their course over the retina, which I regard as pathognomonic signs of bygone swelling; and such a combination of appearances may fairly be interpreted by the supposition that the swelling has disappeared, that atrophy or contraction has set in first in the parts of the disk which were most disturbed, and that the other parts still exhibit residual congestion or residual blood-tinged effusion.

It is needless to say, however, that there are many causes of atrophy besides antecedent swelling. Among these may be enumerated injury, inflicted by some projectile which has missed the eyeball but struck the nerve behind it, or by fracture of the orbital bones; disuse, from disorganization of the perceptive layers of the retina; lead poisoning; and certain forms of sclerosis attacking the nervous centres. The possible varieties of injury are too numerous to be discussed; but I have seen a case in which the optic nerve was severed behind the uninjured eyeball by a child's arrow; and others of an analogous kind have been recorded. The best examples of disk atrophy from disuse, arising from disorganization of the retina, are afforded by the disease presently to be described as "pigmentary retinitis," and analogous instances of partial atrophy are also met with. A little girl, eight or nine years old, was brought to the South London Ophthalmic Hospital with the statement that she had always been blind of one eye. On examination, it was found that the blindness was central only, and that vision was but a little below normal acuteness over the peripheral parts of the field. The ophthalmoscope showed a large and almost circular patch of deeply pigmented effusion, covering the macula lutea and the surrounding region of the retina, and separated from the healthy parts by a sharply drawn line of demarcation. Towards the macula, a considerable section of the optic disk, into which the nerve-fibres from the blind patch would come, was white and wasted, while the remaining portions retained their ordinary aspect. The atrophy attendant upon lead poisoning is generally of very characteristic appearance, the vessels dwindling into the merest threads, and the sunken nerve-surface presenting a peculiar bluish or gray color, around which the

white edge of the sclerotic foramen stands out with much distinctness. In the cases of sclerosis affecting the nervous centres there are generally cerebral or spinal symptoms of a marked character, such, for example, as those of progressive locomotor ataxy. In many instances it is hardly possible to doubt that a prior period of swelling has been overlooked; but, especially in spinal disease, it seems to be quite certain that simple wasting, without preliminary swelling, may occur; and it is believed that certain portions of the cord stand in some special trophic relation with the optic nerve, and that disease of these portions is almost necessarily attended by blindness.

I have met with one instance, and with one only (already referred to in the third chapter), in which atrophy could not be traced to any other antecedent cause than a starvation of the retina by spasm of its arteries. The patient, a lad of nine years old, was brought to the South London Ophthalmic Hospital on account of failing sight. He was fairly grown and nourished, of healthy aspect, and with nothing unfavorable in his family history. The ophthalmoscope showed pale disks, of a bluish-white tint, in each of which the mottling of the lamina cribrosa was conspicuous, and against each of which the edge of the sclerotic foramen appeared of ivory whiteness by contrast with the altered nerve-tissue. The veins were small, the arteries small and pulsating. There was no hardness of the globe; and as an arterial pulse is an evidence that the resistance to the entrance of blood is nearly equal to the propelling force, it was manifest either that the resistance must be in the arteries themselves, or that the heart-power must be deficient. The state of the circulation was carefully examined by Dr. Anstie and by Dr. Sturges; and they reported that the heart was healthy, but that the sphygmograph gave evidence of very high tension in the arterial system generally. The patient was for several weeks under medical treatment at the Westminster Hospital; he then returned to my care, and took pills of phosphorus and nux vomica. He was for a long time under close observation, and I still see him occasionally. The arterial pulsation has ceased, the vessels are of normal calibre, and the progress of the atrophy appears to be definitively stayed. The nerve-disks, however, have not regained their normal aspect, and the vision, which underwent considerable improvement for a time, has for the last two years been stationary—one eye being able to read No. 4 of Jäger's types, and the other, No. 6. It seems hardly likely that there will be any further improvement, neither do I see reason to fear retrogression.

Reverting to the practical aspects of disk atrophy, the first duty of the surgeon, when consulted by a patient whose sight is failing, and whose optic disks are unnaturally pallid, is to endeavor to find out what remote or antecedent cause is underlying the failure of nutrition. It is necessary to remember that the blood supply of the tissue of the nerve-disk is mainly derived

from the vessels of the pia mater,[1] and not from those of the retina, so that a high degree of capillary anæmia of the disk is quite compatible with the passage through it of a well-filled artery and vein. It must also be remembered that the arteries may be contracted from the high tension of their own coats, or by reason of conditions affecting the whole circulation; and that the veins may be distended, prior to the occurrence of œdema or swelling, by intracranial conditions which place some mechanical impediment in the way of the passage of blood from the ophthalmic vein to the cavernous sinus. The influence of such conditions, however, is neither uniform nor well understood; and Mr. Hutchinson has lately communicated to the Clinical Society a case in which the cavernous sinus of the left side was obliterated by the pressure of an aneurism, but in which the internal circulation of the eye remained unaffected.[2] The apparent color of the disk depends greatly upon that of its surroundings; and a degree of capillary vascularity which would give the nerve-tissue a reddish-gray tint in the eye of a fair person, would leave it seemingly pallid when contrasted with the richly pigmented choroid of a swarthy one. Bearing these things in mind, the first inquiry should have reference to tension, and should be directed to ascertain whether the case is one of those insidious forms of chronic glaucoma which imitate atrophy with a most deceptive resemblance. The next point should be to discover whether there had been pre-existing swelling, using for this purpose the test already mentioned, – the course of the veins over the margin of the disk and upon the retina. If there has been swelling, and if atrophy has not wholly superseded it, the erect image may show that portions of the disk are congested, or spotty and turbid, or that the vessels are partly concealed by the effusion which surrounds them. Sometimes there may be evidence of nerve hyperæmia which has not been accompanied by swelling; but I have yet to see an example of this kind which shall leave no room for doubt in its interpretation.

Apart from the appearances presented by the disk itself, the history of the case, or the general condition, may place the nature

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[1] ["The intrascleral part of the optic nerve, *i. e.*, the *lamina cribrosa* and the *papilla nervi optici*, receive, in addition to their twigs from the central vessels, other twigs from the ciliary vessels. . . . . Two or three small branches from the short posterior ciliary arteries enter the sclera near the optic nerve, forming a closed ring, which encircles the nerve and gives off numerous twigs, on the one side to the choroid and on the other side to the optic nerve and its sheath. . . . . Numerous small vessels, veins as well as arteries, pass into the nerve-disk from the margin of the choroidal foramen, so that the fine capillary network of the choroid passes directly over into the coarser vascular network of the intraocular end of the optic nerve. . . . . The trunk of the optic nerve near the eyeball is supplied conjointly by the central vessels and the vessels of the sheath; the intraocular end [*i. e.*, the nerve-disk] is in like manner supplied by the central vessels and the ciliary vessels" Leber, *Graefe und Saemisch*, *Handbuch*, II, I, pp. 306–7.]

[2] [The free anastomosis of the *vena ophthalmica superior*, through the *vena angularis*, with the *vena facialis anterior*, may sufficiently explain the facts as here stated. See Merkel, *op. cit*, pp. 107–110.]

of the affection beyond doubt. The patient may be convalescent from a fever which has been accompanied by meningitis; or may have symptoms indicative of intracranial or spinal mischief, such as headache, vomiting, vertigo, delirium, partial or complete paralysis of certain muscles, or localized pain attended by impaired co-ordination of movement. Sometimes there may be indications of a morbid growth within or pressing upon the nervous centres; and such a growth may be either aneurismal, cancerous, tuberculous, or syphilitic. With a view to treatment, the first question would always be whether there was any physical cause of the atrophy which might be removed, either by surgical means or by the administration of medicines. Mere chronic glaucoma is remediable, within the limits stated in the preceding chapter, by a well-performed iridectomy; and whenever there is high tension, and no background of obvious hopelessness from malignant or other organic disease, the performance of the operation should not be postponed. Even if the atrophy should be partly due to other contributory causes, the iridectomy may yet retard its course, or may promote its repair by permitting an increased freedom of the intraocular circulation. Tubercle, cancer, central nerve degeneration, are changes beyond the present reach of art. But the effusions of meningitis, and the effusions or growths of syphilis, may often be removed by treatment, and may be removed before they have done irreparable mischief. The effusions of meningitis, indeed, are sometimes removed by nature; and I know several instances in which fever patients who have had cerebral symptoms have been only half blinded, being left with nerves permanently blanched, and with an acuteness of vision ranging from one-half to one tenth of the normal. Such a result can only be looked for in children; and, practically, the hope of being able to check the progress of atrophy by treatment is, in most cases, the hope that it may rest upon a substratum of physical change which will be amenable to the influence of mercury or of iodide of potassium. In a case of manifest syphilis, in which the sight was not failing very rapidly, and in which mercury had not previously been given, or had only been given in an ineffectual manner, I should look upon it as the first agent to be employed, and should only relinquish it for the iodide if it were either useless from the first or had ceased to be beneficial. In all other cases I should begin with the iodide, and should administer it in the largest doses which the patient could be made to bear. I know of no other means by which the removal of a physical basis of atrophy can be attempted with the smallest prospect of success.

It is easy to conceive conditions in which adventitious products may have been removed by time or treatment, or may have ceased to contract or to be in any way actively injurious; and in which, notwithstanding, the shock to the nutrition of the nerve may have been too great for its power of vital resistance, so that the process of atrophy may continue after its cause has ceased to be operative. Such conditions suggest the inquiry whether we possess any means

of stimulating nerve nutrition; and the results which sometimes follow the employment of strychnia appear to show that this inquiry must be conditionally answered in the affirmative. The reports of the efficacy of strychnia in nerve atrophy, which have reached us from various quarters, are more favorable than my own experience of its use; but even this compels me to give it a fair trial in many cases. I have administered it to a few patients in whom atrophy has long been stationary, having stopped short of the production of blindness; but in none of these has the slightest benefit been produced. I have administered it in a still larger number of cases of progressive atrophy in which iodide of potassium, preceded or not by mercury, had either failed or ceased to produce improvement. In a few of these cases the effect has been extremely good, and in one something like normal vision has been restored. In several there has been slight improvement, but in the majority no effect of any kind has been perceptible. I am obliged to confess that I do not know of any symptom, or other discoverable element, in a case of progressive atrophy, which will serve as a basis even for an *a priori* conjecture whether strychnia will be useful or not. I presume the conditions of its usefulness must be those which I have just stated; namely, that the direct operation of the primary physical cause of the atrophy must have ceased, and that the nerve must simply be languishing from the effects of the injury which it has received. I do not know how to find out whether these conditions exist; and so I give strychnia experimentally and watch its action. I say, in effect, to a patient with nerve atrophy, in whom some sight is still preserved, and in whom there is no evidence of essential incurability, that he ought not to submit to blindness until he has fairly tried full doses of iodide of potassium, and afterwards full doses of strychnia.

I administer strychnia in every case by hypodermic injection; and have not found any difficulty, when medical attendance for the purpose has been for any reason inaccessible, in teaching some member of the patient's family to perform the little operation. I direct the patient to provide himself with a vulcanite syringe, fitted with very fine, sharp, steel needles, and graduated on the stem of the piston. Such an instrument can be procured for a few shillings. I prescribe a solution containing one grain of sulphate of strychnia in three drachms of distilled water, so that a sixtieth of a grain is contained in three minims. This quantity is injected twice a day for a week. At the beginning of the second week each dose is increased to four minims, at the beginning of the third week to five minims, and at the beginning of the fourth week to six minims, so that the patient then receives the thirtieth of a grain twice a day. At the beginning of the fifth week I double the original strength of the solution, and return to the original quantity of three minims, which is again increased as before. I continue gradually increasing the dose in this way until twitching or other evidences of the effect of the medicine are produced, when the quantity is somewhat diminished, and the administration con-

tinued for a fortnight. At the end of that time, if no improvement has followed, I abandon the strychnia as useless in the case. If there is improvement I continue the strychnia as long as the improvement continues, and increase the dose as soon as the improvement flags, until further increase is checked by symptoms of poisoning. I direct the patient always to have at hand a draught containing twenty-five grains of chloral hydrate, to be taken as an antidote if any injection should be followed by troublesome or alarming consequences; but these seldom or never occur, and some people will take very large quantities without perceptible effect. One gentleman who was under my care increased his dose to nine minims of a solution containing seven grains of the sulphate of strychnia in four drachms of distilled water (or more than one-fourth of a grain of the salt), and took this twice a day for several days, before twitching was produced. I am sorry to add that he derived no benefit as far as vision was concerned.

Besides the employment of strychnia, the stimulus of functional use should be regularly applied. The eyes should be freely exposed to light; and attempts to read should be made daily, the patient always taking the smallest type which he can puzzle out by the aid of a strong magnifier. Some time ago it was hoped that continuous-current galvanism might be a valuable adjunct to strychnia. Dr. Anstie and myself tried it in several cases; but we never met with one in which it produced the smallest change for the better, either in the appearance of the nerve or in the vision of the patient. I have watched the disk over and over again while the current was applied both to the neighboring parts and to the cervical sympathetic, and I have never seen it produce even a temporary change in the diameter of the retinal vessels.

When ophthalmic surgeons regarded nerve-atrophy chiefly as a substantive disease, which had already made some progress before failing vision was complained of, and when they were unacquainted with its common origin in nerve swelling, which often escapes notice because it does not affect the sight, speculations as to the causes of atrophy were rife. Among those most commonly assigned, tobacco and alcohol held prominent places; but held them, I venture to think, upon very feeble and insufficient evidence. Eleven years ago, in the notes to my translation of Zander's *Augenspiegel*, I referred to this question at some length, and pointed out the analogy between atrophy and cirrhosis; although, not being then aware of the antecedent occurrence of disk swelling, I stated as a difficulty that I had never seen subretinal serous effusion. I quoted a letter from Dr. Dickson, the physician to the British Embassy at Constantinople, to the effect that the consumption of tobacco in that city averaged about three pounds weight per head per month for the whole population, but that "amaurosis" was a "rare affection" there; and also a letter from Dr. Hubsch, the principal oculist in Constantinople, who confirmed Dr. Dickson's statement with regard to the small number of cases of nerve blindness, and who added: "Quant à l'action du tabac sur les yeux, elle

est très problématique; ici tout le monde fume du soir jusqu'au matin, et du matin jusqu'au soir; les hommes fument beaucoup, les femmes un peu moins que les hommes; et les enfants fument dès l'âge de sept à huit ans. Je n'ai jamais pu attribuer l'amaurose à l'abus du tabac; le nombre des fumeurs est immense, le nombre des amauroses est limité. La fumée détermine souvent, chez les personnes qui ont la peau et la conjonctive très délicates, des irritations chroniques, des congestions locales, ou des blépharites ciliares avec perte des cils, larmoiement continu, et rougeur plus ou moins intense. Voilà pour l'action du tabac." I have obtained the same kind of negative evidence from Egypt and India; and in the face of it, taking into account the difficulty of distinguishing between causation and coincidence, I do not attach much importance to the fact that several patients who have suffered from nerve atrophy have been "great smokers." It is possible that an amount of evidence, equally large and equally trustworthy, might be obtained in order to connect the disease with black hair, or with any other common personal peculiarity; and it is to my mind conclusive that, although the consumption of tobacco has greatly increased of late years, I have no experience of any parallel increase of nerve-atrophy.[1] With regard to drink, again, I can only connect atrophy with it in this general way,—that every malady which assails a drunkard is probably in some remote degree dependent upon his vice. I doubt whether an asylum for inebriates would contain a much larger proportion of cases of nerve-atrophy than any other assemblage of persons taken from the same ranks and the same periods of life. The example of lead shows that it is possible for chronic poisoning to act chiefly upon special portions of the organism; but among the small number of cases of lead poisoning the proportion of cases of optic nerve-atrophy is very large, while among the immense army of drinkers and smokers it is probably little larger than among the whole community. If a patient drinks to excess, whatever may be his disease, it is

[1] [A very large proportion of the cases of optic-nerve atrophy which have fallen under our own observation have been in cigarmakers and workmen in tobacco factories. Such persons ordinarily use tobacco very freely, both by smoking and chewing, but are not especially addicted to drinking. It is our belief, also, that inveterate drinkers, who, however, are very apt to be also inveterate smokers, are especially liable to suffer from amaurotic affections. Nerve-swelling has not appeared to us to be a marked feature in these cases, but our observation has seemed to coincide with that of Mr. Hutchinson who believes that a stage of hyperæmia of the disk is the usual forerunner of the atrophy. In the way of treatment it has been our habit to rely chiefly upon the immediate and total abandonment of the habits which have seemed to us to have contributed to the development of the disease, and this abstinence has been so often followed by prompt and permanent improvement as to confirm us in the belief that we have recognized and removed a principal and efficient cause of the trouble. Conjointly with abstinence from smoking and drinking, we ordinarily prescribe bichloride of mercury, in the dose of $\frac{1}{16}$th or $\frac{1}{24}$th of a grain three times a day, and in the later stages of the disease it has appeared to us that much benefit has followed the employment of hypodermic injections of strychnia.

These views are, so far as we are informed, substantially those of ophthalmic practitioners generally throughout the United States; it seems quite probable, also, that American tobacco may be more deleterious than that of Turkey and the East.]

part of the duty of the physician to endeavor to bring about the abandonment of this habit; and if a patient who consults me on account of nerve-atrophy is a smoker, I always advise him to lay aside tobacco as an experiment, and the larger his ordinary consumption the more stringent would be my injunctions in this particular. But they would be dictated almost entirely by the duty of leaving nothing undone in such a case, and would not represent any personal belief in the necessity of the prohibition.

At the time when Von Graefe was endeavoring to arrive at some conclusions about the nature of atrophy from the character of the subjective disturbance of vision, it was the custom in Germany to treat the disease by the administration of copious draughts of Zittman's decoction, a diuretic and diaphoretic drink. This practice had, as an auxiliary, a rational basis so far as this, that many of the patients are loaded with waste products, the result of overfeeding, sedentary habits, imperfect excretion, and mental anxiety. We cannot expect one who is so circumstanced to effect, even with the aid of iodide of potassium, the removal of an adventitious deposit; neither can we expect one whose general nutrition is impaired to overcome a local tendency to atrophic change. In addition, therefore, to the treatment already recommended, I would urge that the diet, the excretions, and the habits of life, should be regulated with the most scrupulous care, and that the surgeon should encourage quite as much hopefulness as the circumstances of the case will justify.

Passing on from the optic nerve to the retina, it is manifest, if we consider the continuity of the two structures, that the changes which occur in the former must frequently extend to the fibre layer of the latter. When this happens, the retina itself becomes more or less swollen, œdematous, and opalescent or opaque; and its tortuous veins, which in their bends approach or recede from the observer, appear interrupted, being visible where they rise to the surface, and concealed where they dip down into the altered and thickened tissue. These changes are most conspicuous near the optic disk, and gradually diminish towards the equator, being also absent in the region of the macula lutea, where there is no fibre layer in which they can occur, and where the still transparent tissue allows the red color of the choroid to be seen in such marked contrast to the surrounding opalescence that it often resembles a hæmorrhagic spot. When hæmorrhage really occurs, the blood mostly follows the course of the retinal nerve-fibres, and is forced by them into an arrangement which more or less maps out their distribution. The conditions thus described have been called retinitis, or neuro-retinitis; but I see no sufficient evidence that they possess an inflammatory character, or that they differ essentially from the œdema or varicosity consequent upon obstructed venous circulation. They probably indicate that the obstruction is greater in degree, or the vital resistance of the tissue less, than in the cases in which the swelling is almost limited to the disk; and they are attended by serious impairment of vision, which may

be attributed to the disturbance of the retinal circulation and nutrition. Pathologically and therapeutically, they can only be regarded as aggravated examples of choked disk, more severe than others, more likely to terminate in atrophy, calling for the closest possible inquiry into the antecedent or underlying conditions, but not presenting any characters which will place them in a class by themselves.

Another form of retinal change from obstructed circulation is that which is produced when the central artery becomes plugged by an embolus In such cases, as a rule, there is valvular disease of the heart, followed by sudden blindness of one eye; blindness which may either occur in the daytime, or be discovered on waking from sleep. If the plug is lodged on the hither side of any considerable branch, the part of the retina supplied by that branch may retain vision; but, generally speaking, the plug is altogether behind the division of the artery, the branches are all deprived of blood, and the blindness is complete. The ophthalmoscopic picture is very characteristic. The arteries contract and empty themselves, and are either lost to sight entirely, or are seen only as fine threads. In the veins, the blood often becomes interrupted, or broken into detached portions, which are separated by empty spaces, and which sometimes oscillate to and fro. The nerve-disk, deprived of arterial blood, looks whiter than usual, and the fibre layer of the retina becomes of almost milky whiteness and opacity, quite shutting out the color of the choroid, except at the still transparent macula, which appears as a sharply defined bright red spot. In one of my cases, a very small arterial branch was given off just behind the embolus, and emerged upon the margin of the disk just within the sclerotic foramen. When the embolus was driven home, this small branch yielded to the stress suddenly thrown upon it; and the optic disk became covered with a film of arterial blood, which was entirely absorbed in about a week. When a large branch escapes the embolus, the ophthalmoscopic appearances differ from those above described in that some portion of the retina may remain unchanged. There is no remedy for these cases, which, fortunately, are scarcely liable to be met with in both eyes of the same patient. After a variable time the retina regains its transparency, and the optic nerve becomes atrophied. The atrophy produced by an embolus may always be recognized by the history of the case, by the disappearance of the arteries from the nerve-disk, and by their appearance, as delicate white threads, on those parts of the retina which have regained transparency.

Among the varieties of retinal change which have been described as this or that form of retinitis, the leucæmic, the syphilitic, the albuminuric, and the pigmentary, none but the last mentioned appears to me to be properly an inflammation; the others being the results of degeneration or infiltration of various kinds, perhaps sometimes complicated by inflammation of a secondary character. The symptoms of pigmentary retinitis are so

members of a family; insomuch that I now never see a case of it for the first time without requesting that the brothers and sisters of the patient may be sent to me for examination. It varies greatly in the rapidity of its progress; and Professor Donders says that there may be a period of twenty years or more between the first appearance of the symptoms and the final extinction of sight. I have seen sight all but extinguished by it in a lad only ten years of age; and I have other cases under observation in which the lapse of two or three years has been attended by little increase. The patients are of all descriptions, of both sexes, young and old, healthy and diseased, feeble and vigorous. The patient whose field of vision is shown in Fig. 15, page 72, is a robust and healthy-looking girl of twenty, with rosy cheeks, well-developed muscles, and a remarkable set of sound strong and shapely white teeth. Her younger sister, who is less conspicuously healthy-looking, is also affected. I have never been able to connect the disease with syphilis, either inherited or acquired; but I think that the peculiarities of its seat and of its mode of increase point out that its analogies are with some of the chronic skin diseases, and that, like them, it is probably localized by the anatomical distribution of nerve influence; conjectures which derive some support from the history of the embryonic development of the eye. In the way of treatment I have nothing to say, except that I usually give iron in rather full doses, generally the tincture of the perchloride, and that I think this preparation has a tendency to arrest the progress of the malady. It is difficult to say this with any certainty, when that progress is naturally so slow, and when it may probably be accelerated or retarded by various conditions which it would be impossible to take into account. But I find that many patients believe in the iron. They take it for two or three months, become tired of it and lay it aside, and then come back after a time to ask for it again, saying that they get worse without it. Professor Quaglino once announced that he was obtaining great results by repeated paracentesis, and promised to publish full accounts of his cases when they were complete. I fear the issue disappointed him, for I have not heard that he has written anything more upon the subject. I have not felt tempted to try his method; and I confess that my only hope of the discovery of any curative agency rests upon the progress of research with regard to the influence exerted upon local nutrition by individual nerves.

Proceeding to the degenerations of the retina, the most important of them is that which is so often associated with albuminuria. It has long been known that vision is often much impaired in the advanced stages of Bright's disease; and the impairment was often cited, in the pre-ophthalmoscopic period, as an illustration of the power of depraved blood to diminish the functional activity of the nervous system. Now, however, it is well ascertained to rest upon a basis of physical change, which appears to consist chiefly of fatty degeneration, with scattered patches of arterial hæmorrhage. The ocular phenomena seem to support Sir William Gull's

belief that Bright's disease has its origin in conditions which affect the arterioles of the body generally, and not merely those of the kidneys; for the retinal degeneration in some cases precedes the presence of albumen in the urine, and is mostly a very early symptom, although sometimes it only appears at a late period. Hence it certainly cannot be said to be caused by the albuminuria; and clinical observation rather points to the renal and ocular disorders as common consequences of the same antecedent. If we may assume this antecedent to be disease of the coats of the arterioles, which weakens them, and at the same time obstructs their channels, it is easy to conceive the manner in which fatty degeneration may take the place of natural repair, and in which hæmorrhagic spots may be produced.

The appearances seen with the ophthalmoscope in these cases are subject to much variation as regards the extent of the departures from the natural state; but the general tendency of the patches of fatty deposit is to group themselves more or less symmetrically around the optic disk, or the macula lutea, or both; and the general tendency of the blood effusions is to occupy the fibre layer of the retina, becoming more or less fibrillated in appearance, and spreading out into somewhat brush-shaped extremities. The patches are generally white or cream-colored, reflecting light strongly; and their position in the anterior layer of the retina is shown by the fact that they conceal the smaller vessels entirely, and often partially conceal the large ones. They are thus at once distinguished from subretinal effusion, which would throw the retinal vessels into relief and render them unusually conspicuous. It was at one time believed that a stellate arrangement of white dots around the macula, together with a zone of similar degeneration, sprinkled with hæmorrhages, around the nerve-disk, was pathognomonic of albuminuria; but I have already mentioned one instance of such changes in a case in which death was produced by a tuberculous deposit in the cerebellum, the kidneys remaining healthy. In this instance there were manifest indications of intracranial mischief; but we also meet with persons whose only complaint is of failing sight, and in whom the ophthalmoscope shows a few glistening flecks in the retina, either with or without small hæmorrhages, and whose urine is not albuminous. When such patients are persons who have passed the middle period of life, I think we may generally look for the development of renal disease in them before long: and that the appearances within the eye must be held to point to a degeneration which is not local only, and to call for the most careful investigation of the constitutional state and of the habits of life. As a rule, however, the urine is already albuminous in such cases; and in hospital practice it is a matter of frequent occurrence that the ophthalmoscope leads to the discovery of albuminuria in persons who apply on account of failing sight, and who are then transferred to the medical department for treatment. The alterations in the retina generally un-

dergo only gradual increase; and death often occurs before complete blindness is produced.

In a few cases, however, and these chiefly in young adults, we meet with retinal changes of a somewhat different character, in which there is a large element of effusion, which are associated with renal disease of an acute type, and which seem, if not actually inflammatory, to be at least due to a sympathetic irritation of the retina. The most remarkable instance of this kind which I have met with was in the case of a lady who came to me from the country about a year and a half ago, on account of sudden dimness of sight of the left eye, which could only read No. 19 of Jäger, letter by letter. She was in a high degree short-sighted ($M = \frac{1}{3}$); and my note at the time was "retinal effusion and œdema of disk." I said that the condition of the eye might be due to kidney irritation; and then learned that she had long been subject to attacks of hæmaturia. She went at my request to Dr. Dickinson, who informed me that there was a trace of albumen in the urine, and that he suspected a renal calculus. We prescribed a mixture containing ammonio-citrate of iron with iodide of potassium, and the patient went a long journey by railway. Immediately on reaching her destination she was attacked by profuse hæmaturia, for which she had recourse to her customary medicine, the tincture of perchloride of iron in large doses. The bleeding ceased in a few days, and the vision of the left eye began to improve. Three weeks after her first visit I saw her again. The subretinal effusion had entirely disappeared, the disk was of normal aspect, and the eye could read "brilliant" type, although this was said to look "a little misty." I advised cupping on the loins if the sight again became impaired, but have since heard nothing further of the patient.

The most extensive retinal changes which I have seen in connection with albuminuria have been in cases of acute renal disease occurring in young women during pregnancy; and in these the sight is commonly more impaired than in the chronic disease of older subjects. The appearances of fatty degeneration, and the hæmorrhagic patches, are often complicated by a good deal of general retinal œdema, which produces a diffuse milkiness or opalescence of the fundus; and this œdema often disappears, and sight improves in a corresponding degree, under the influence of the treatment which is demanded by the state of the kidneys. In hospital practice, however, the eventual termination is almost always unfavorable, both as regards vision and as regards life. I have never seen the former return, even for a time, to the normal standard; and the kidney disease generally passes from the acute into a chronic form, and proves fatal within a year or two.[1] As

[1] [We have seen a well-marked case of albuminuric retinitis in which conspicuous retinal opacities cleared up in both eyes, and vision, which had been nearly abolished, rose to 16–XX. The patient, an unmarried woman of about thirty, died a year later with all the symptoms of Bright's disease.]

regards the retinal changes which are associated with albuminuria, there is nothing to add to the treatment of the renal disorder. The frequent coexistence of the two conditions should lead every medical man, even if he does not use the ophthalmoscope, to examine the urine for albumen in every case in which defective sight is complained of, especially in patients who are approaching the grand climacteric, and in young women during pregnancy. If this precaution is omitted, disease of the kidneys will assuredly often escape detection.

The cases of syphilitic retinal deposit or degeneration usually present little difficulty, not so much on account of anything absolutely characteristic in the appearances, as because, in most instances, the history is not doubtful. The deposit is sometimes general, more often partial; and in the latter case it differs from albuminuric degeneration in the absence of any tendency to symmetrical arrangement, and also, as a rule, in the absence of any hæmorrhagic spots. The deposit, instead of being grouped around the disk or macula, appears in isolated grayish or white patches here and there, patches which are often of highly irregular outline, and which may send out long processes or bands in different directions. When the deposit is general, it produces only a diffused milkiness or increased visibility of the retina, together with more or less veiling and obscuration of its bloodvessels, these changes being most visible around the disk, where the retina is thickest, and gradually diminishing towards the equator. One of the best examples of this kind of disease which I have met with occurred in a married woman, who came to St. George's Hospital after having passed through the acute stage of double syphilitic iritis. Her eyes were still irritable, and the pupils almost universally adherent. I removed a large piece of iris from each eye, opening good pupils, and put her under constitutional treatment, which, fancying herself well, she discontinued prematurely. About a year afterwards she returned, on account of failing sight. The superficial parts of the eyes were quite healthy, but the ophthalmoscope showed extensive opalescence of both retinæ, which, under renewed constitutional treatment, cleared away again in some degree. It is characteristic of syphilitic retinal change that its aspect varies, sometimes even from day to day, that it is chronic and intractable, and that it tends to frequent relapse. Even in mild cases, the vitreous body in the immediate vicinity of the retina generally participates in the disorder; and may often be seen by the direct method, and by carefully managed illumination, to be beset by fine particles, which M. de Wecker has aptly compared to the motes in a sunbeam. In more severe cases the vitreous often becomes turbid throughout, so that the retinal changes are no longer visible. The termination of syphilitic retinal disease is either in atrophy or in partial or entire recovery; the nature of the result depending upon the severity of the attack, upon the severity and duration of the constitutional malady, upon the degree of discretion exercised in the treatment, and upon the cir-

cumstances and recuperative power of the patient. The treatment of constitutional syphilis does not require to be modified because the retina is one of the parts attacked, although this circumstance, from the grave issues which it involves, adds very materially to the responsibilities of the surgeon.

Next after the albuminuric and syphilitic forms of disease, the most important changes which are met with in the retina are hæmorrhages, which may be either venous or arterial. It has already been mentioned that arterial hæmorrhage may form part of the albuminuric degeneration ; but I now speak of hæmorrhage as it exists alone If an eye is examined soon after the rupture of a retinal bloodvessel, it is usually possible to determine, by the color of the effusion, whether an artery or a vein has given way ;[1] and in many cases the collapsed vessel may be traced beyond the hæmorrhagic spot, and thus positively identified. When some time has elapsed, and when the effusion of blood has been too considerable to be readily absorbed, the remains are apt to become infiltrated by pigmentary deposit, and the tissue disturbance is often followed by inflammatory changes which lead to partial atrophy, and which may thus disguise the character of the original conditions. Arterial hæmorrhage in the retina is generally due to weakness of the coats of the vessels, or to increased strain upon them, or to both these causes combined ; so that it leads to a suspicion of atheroma, or of the vascular degeneration which is said by Sir William Gull and others to underlie Bright's disease, or of hypertrophy of the heart; and calls for careful examination with reference to all these changes. The degree in which it will affect vision will chiefly depend upon its extent and its situation in the retina, a large bleeding sometimes causing sudden and complete blindness, a small and peripheral one scarcely producing any impairment of sight at all. Small arterial hæmorrhages, however, are always of grave import, because the conditions under which they are most liable to occur are emphatically conditions of degeneration; and hence the rupture of a retinal artery is not unlikely to be the precursor of the rupture of an artery in the brain. In such instances, therefore, it is proper to tell the patient that his malady affords a warning which may protect him from more serious evils ; and to advise him with reference to his habits of life in such a way that the warning may be fruitful. Not many months ago, in the case of an elderly gentleman who consulted me with regard to his spectacles, I found the retina of one eye, towards the equatorial region, studded with minute blood-spots which were traceable to ruptured arterioles. Further examination led to the discovery that his heart was much hypertrophied, and he was thus induced to seek and to follow counsel, with reference to his habits and regimen, by which I have no doubt that his life will be considerably prolonged.

Hæmorrhage from retinal veins usually occurs, I think, from

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[1] [This statement appears to us to be at least doubtful.]

larger vessels than those which are the ordinary sources of arterial hæmorrhage; and hence it is often somewhat abundant. It has been already mentioned as a mechanical consequence of the obstructed circulation in cases of choked disk; or it may be produced by violent muscular effort, as during an epileptic fit or a paroxysm of coughing (I have seen one instance in which it took place during parturition); or it may depend upon a depraved state of the blood itself, as in scurvy, hæmorrhagic purpura, or leucæmia. It occurs also in women at the time of cessation of the catamenial function, as a result of one of the local congestions or disturbances of circulation which are incidental to that period of life. The appearances presented by venous hæmorrhage will depend partly upon the quantity of the effused blood, and partly upon its situation. It may be situated either immediately beneath the [internal] limiting membrane, when it will appear simply as a uniform dark-red patch of variable size and sharply defined margin, concealing everything behind it from view; or it may be situated in the substance of the fibre layer, in which case it will be widely and somewhat irregularly distributed, in a manner generally corresponding to the distribution of the fibres themselves, and serving to map out their course and their broad lines of curvature. In such a condition there may still be distinct blood-deposits scattered over the surface; but the margins of the deposits will not be sharply defined, and the retina as a whole will be more or less stained or tinged. Even under the most favorable conditions, every hæmorrhagic patch produces a blind spot, or gap in the field of vision, of magnitude corresponding to its own, by shutting out the access of light to the percipient layer beneath. Sometimes the blind spot may be much larger than the hæmorrhage, chiefly when the latter has so disturbed the retina as to stop the conduction of impressions through the fibres which are affected. When a hæmorrhage is not very extensive, and especially when it does not penetrate into the fibre layer, but remains spread out as a film beneath the limiting membrane, it may be entirely absorbed with little or no impairment of vision. When it is considerable in amount it often leaves an opaque patch of decolorized fibrin, in and around which a deposit of pigment commonly takes place.[1] When the bleeding has been attended by much tissue disturbance, inflammatory reaction is apt to follow; and, either with or without this complication, the case will generally terminate sooner or later in atrophy. The hæmorrhage least to be feared is that which occurs in women towards the close of menstrual life, and the form most likely to be destructive to sight is that in which blood-spots are scattered about in a generally stained fibre layer.

In determining the treatment of retinal hæmorrhage, we must be guided mainly by the systemic conditions to which it can be

[1] [Pigment deposits in the site of an old retinal extravasation indicate that the deeper layers of the retina have been involved either primarily or through subsequent inflammation.]

traced. In purpura, or in scurvy, or in women ceasing to menstruate, we may at least hope to prevent any recurrence of the accident, and often to bring about absorption; while in cases of arterial disease, or of hypertrophy of the heart, our functions will be practically limited to endeavors to prevent the still more serious mischief by which the patient is threatened. When much local congestion is present, depletion by Heurteloup's artificial leech is almost always indicated, followed by the usual precaution of confinement to a darkened chamber for twenty-four hours; and employment of the eyes must in all cases be strictly forbidden so long as the probable causes of the hæmorrhage are still in active operation. When there is no other special requirement in the way of medicine, I am accustomed to prescribe the iodide and bromide of potassium in combination. It is very difficult to obtain trustworthy evidence upon such a point, but I think that these salts promote absorption of the effused blood, and I am sure that they exert a beneficial action upon some of the forms of congestion by which bleeding may be produced. In favorable cases, as the clot or film is seen to clear away, vision returns in corresponding proportion; and may at last be entirely restored. After the blood has disappeared, it is not uncommon for the patient to say that all objects have a wavy or broken aspect; the lines of print, for example, seeming to pursue a curved or an irregular course. There can be little doubt that this phenomenon is due to the presence beneath the limiting membrane of some residual transparent effusion, by which the natural contour of the retina is disturbed, and the image formed upon it is distorted.[1]

In all the varieties of degeneration or infiltration of the retina, or of hæmorrhage among its fibres, we may have consequent inflammation, which I look upon as being essentially traumatic in its character, the result of the laceration or displacement of tissue, of the irritation caused by the presence of an adventitious deposit, or of the derangement of the natural order of the circulation. I have little or no belief in the various forms of "retinitis" described by writers; the albuminuric, the syphilitic, the leucæmic, the apoplectic, and what not; but look upon [the retinitis in] them all as being essentially the same process, springing out of conditions which, if not identical, are very closely analogous to one another. Syphilitic retinitis is the resentment of a retina incumbered by syphilitic deposit. Apoplectic retinitis is the resentment of a retina split up and partially disorganized by hæmorrhages. The inflammatory process, in every case, adds swelling, turbidity, and effusion, to the pre-existing changes. The effusion is often of a plastic character; and after the subsidence of all acute disease may remain in permanent patches or bands upon the membrane. Such patches or bands are occasionally met with in eyes which

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[1] [This statement is not quite clear; this symptom, which is known as *metamorphopsia*, is probably attributable to a slight displacement of the percipient retinal elements, which may be dependent on effusion or on cicatricial contraction.]

have never had good vision; and in which they must be attributed to inflammation during early infancy, or even during intrauterine life. They are generally white or grayish-white in color, often with white striation upon a gray ground; and they have a peculiar lustre of surface, which may be compared to that of satin, or of mother of pearl. When the inflammation is severe, it leads almost necessarily to atrophy, first of the retina, and subsequently of the optic disk; the origin of the wasting in the retina being shown by the extreme dwindling of its arteries, which sometimes almost entirely disappear. The treatment of the inflammation resolves itself into that of its exciting cause; and the prognosis, which must generally be very unfavorable, is perhaps less so in syphilitic cases than in most others, because syphilitic deposit is more amenable to treatment than either hæmorrhage or fatty degeneration. At the same time, some of the very worst and most hopeless cases are those of a syphilitic character, in which not only the retina, but also the vitreous humor and the choroid, are early and seriously involved. The morbid changes may, indeed, be brought under the control of treatment; but not until they have produced structural alterations of a kind which destroy all hope of the restoration of functional utility.

Under certain circumstances the retina becomes detached from the choroid, and raised up, like the pellicle covering a blister, by subjacent effusion. Some of these cases are traumatic, produced by blows on the head; others are not traceable to obvious causes. A patient will say that he experienced sudden loss of the upper or the lower portion of his field of vision. When the upper part of the field is lost, a common comparison is to liken the effect to that produced by the peak of a cap coming low over the eye; and, when the lower part is lost, the patient will say that he can no longer see objects which are lying beneath him. In traumatic [and other] cases the loss of vision is sometimes bounded by a vertical or oblique line instead of by a horizontal one. In ophthalmoscopic examination, if the pupil is not dilated, a small detachment of the retina is a change which it is very possible for an inexperienced observer to overlook. The detachment, if present, will be found in a direction opposite to that of the blindness; in the lower half of the retina when vision is lost above; in the upper half when vision is lost below. It appears as a tremulous projection, of a dirty white [or greenish-gray] color and sheeny surface, crossed by the retinal vessels; and when large it falls into undulating movements, which resemble, on a minute scale, those of the artificial waves of a theatre. As the subretinal effusion increases in quantity, the detachment increases in magnitude; and it may ultimately fall across the area of the natural pupil, excluding direct rays from any portion of the retina which may still preserve its function, and so reducing vision to perception of light. The increase is most rapid when the original detachment is in the upper portion of the retina, as the separation of the remainder is aided by the gravitation of the fluid. Detachment of

the retina admits of little treatment. In a few cases, spontaneous rupture of the detached portion has been known to occur, followed by its return to its natural position, and by a certain amount of improvement of sight.[1] Guided by these cases, Von Graefe suggested artificial laceration, as a course which might be expected at least to prevent the increase of the detachment. Soon after making this suggestion he was for a few days in London, and I sent up for his opinion a man in whom detachment had followed a blow on the orbit by a splash of lead from a rifle-target. The patient was a healthy man in the prime of life, and the eye before the accident had been perfect; so that the case was a very favorable one for the operation. Laceration of the projection was performed by Mr. Bowman, Von Graefe and myself being present, and we satisfied ourselves by ophthalmoscopic examination that the mechanical effect which was wished for had been perfectly obtained. Not the slightest improvement of vision was produced, either at the time or subsequently; and since then I have myself operated on many cases with the same negative result. It is said that in some instances benefit has followed the operation; and hence it ranks as one which may be fairly tried, although my own experience does not enable me to recommend it, or to urge its performance otherwise than by saying that it may possibly do some little good and that it is not likely to do harm. The position of the detachment having been carefully determined, the surgeon thrusts two cataract-needles through the corresponding part of the sclerotic and choroid, through the effused fluid, and through the detached retina, into the vitreous body, taking care not to injure the ciliary region or the crystalline lens. The distance apart of the punctures must be determined by the size of the detachment; but they must both be well within the limits of its base. The shafts of the needles must converge, so that they may cross one another after they have penetrated into the eye. The points are then to be separated by approximating and crossing the handles, so that the shafts may be rendered divergent, and may tear a rent in the portion of retina which lies between them. The subretinal effusion will pass through this rent to mingle with the vitreous, and the retina will fall back to its normal contact with the choroid. As the needles are withdrawn, the drop of fluid which exudes from each puncture should show, by its viscous character, that it contains a portion of vitreous humor, and that hence the retina has actually been pierced and divided. The subretinal fluid is often somewhat turbid, and may place an obstacle for a time in the way of the ophthalmoscopic view. Sometimes much irritation is produced, by which the turbidity of the vitreous may be maintained or increased; and in one or two instances I have seen the operation followed by an insidious iritis. Gener-

[1] [Five cases of spontaneous absorption of subretinal fluid with restoration of the function of the retina, are reported in the *Transactions of the American Ophthalmological Society* for 1875. Eight other cases, spontaneously cured, are also referred to, but not reported, in the same volume.]

ally, however, either immediately or within a few days, the rent in the retina becomes visible; and the effect of the treatment may then be fairly estimated. Attempts have been made, by M. de Wecker and others, to procure the subsidence of the detachment without laceration, by drawing off the subjacent fluid through a sclerotic opening. M. de Wecker employed a fine canula for this purpose; but I have no personal experience of such treatment, and should expect the fluid to be again secreted before any long time had elapsed.

Detachment or elevation of the retina is not occasioned by fluid effusion only, but also by morbid growths, and occasionally by the presence of a cysticercus. The latter is not very rare in Germany, and in other countries in which tapeworm is more frequently met with than among ourselves; but I have never seen a case, and I do not know that one has been recorded in England.[1] A cysticercus usually first appears as a subretinal prominence, which increases in size, and in time breaks through into the vitreous. Within this prominence, as long as it it unbroken and sufficiently transparent, the retractile neck of the parasite may be seen and recognized; but after rupture of the retina, and sometimes even before, the true nature of the case may be concealed by turbidity of the media. An eye containing a cysticerus must undergo destruction if left alone; and the only possible treatment is by the enucleation of the globe or the extraction of the parasite. It is unnecessary to discuss the methods by which the latter object might be accomplished, inasmuch as they would vary with the peculiarities of each case, and inasmuch as the matter is only of small importance among a people who do not make raw flesh a staple article of diet. Even under the most favorable circumstances, the operation would hardly preserve vision; but it might save the patient from much pain, and at the worst would probably leave a stump well suited for carrying an artificial eye.

The morbid growths by which the retina may be elevated are of two classes; sarcomata, which originate in the choroid, and gliomata, which originate in the connective tissue (neuroglia) of the retina. The former are extremely rare;[2] but when they commence in the posterior hemisphere of the eyeball, and project into the vitreous cavity, carrying the retina before them, they produce at

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[1] [A case of cysticercus of the iris is recorded by Mr. Teale (R. L. O. H. Rep., V, p 320), and one of cysticercus in the vitreous, by Mr. J. Soelberg Wells, in his *Treatise on the Diseases of the Eye*, Chap VII, 3.]

[2] [Choroidal sarcoma, often darkly pigmented, and then called melano-sarcoma or melanosis, is by no means an excessively rare disease, and occurring, as it almost always does, in persons past the period of infancy, it is often detected in its earlier stages, in which, perhaps, the only symptoms are partial failure of vision and limitation of the visual field; in other words, the same symptoms as those of detachment of the retina, which, moreover, soon takes place, and for a time may mask all other signs. The possibility of the early detection of choroidal sarcoma enables the surgeon to remove it early, and this, taken in connection with the fact that the choroid is anatomically less directly continuous than the retina with tissues external to the eyeball, renders the prognosis, after enucleation of the globe, much more favorable than in retinal glioma.]

first a distortion of the apparent shape of all objects, in the manner already described when speaking of the elevation of the retina which is sometimes left after the disappearance of a blood-spot.[1] With the growth of the tumor the distortion of objects would increase, and the projection of the retina, if not at once conspicuous, would be rendered manifest in the direct ophthalmoscopic examination by the strength of the convex lens which might be employed in looking at its summit. The presence of a tumor within the eye, moreover, necessarily [sooner or later] occasions increased tension; while in ordinary cases of retinal detachment the tension is almost invariably subnormal. A sarcoma, in its increase, would soon produce effusion or inflammation, and would greatly impair vision by interference with nutrition and by pressure, so that the diagnosis could not long be doubtful; but in an early stage much uncertainty might often be felt. The distorted aspect of things, coinciding with increased tension and with projection of the retina, would not indeed afford evidence of the character of the growth, but would render it almost certain that a growth of some kind must be present.

The gliomata include the cases which were formerly described as encephaloma of the eyeball. They occur chiefly in children and young persons,[2] and are seldom recognized until they have attained considerable magnitude. The common history is that parents observe one eye of a child to return a white or yellowish reflex from its pupil; and on closing the other they discover that the affected eye is blind. The surgeon finds increased tension, projection forwards of the iris towards the cornea, and, generally, dilatation of the pupil. The lens will be transparent, and its high refractive power will be rendered conspicuous (as that of a diamond by its foil) by a mass of white or primrose-yellow substance lying behind it. This substance, when examined by the direct image or by focal illumination, has a homogeneous, finely granular aspect, and may or may not be traversed by bloodvessels. In a still earlier stage, before the glioma has projected into the vitreous chamber, it may be seen as a patch or patches on the retina; and the unaffected portions of the latter may retain vision. The visible growth of the white or yellow patches, and the invasion of portions previously unaffected, would leave no doubt with regard to the nature of the disease. In a later stage, as the tension of the eyeball increases, pain and inflammatory reaction are produced; and the disease, like sarcoma, if not cured by timely removal, spreads along the optic nerve and tract to the brain, and destroys life either as intracranial cancer, or by the projection of a bleeding fungus from the enormously enlarged and distended eyeball.

The only treatment of either [choroidal] sarcoma or retinal

[1] [This can occur only when the choroidal tumor happens to be developed in the region of the macula lutea, and even then the stage of distorted vision must soon give place to a stage in which loss of central vision will be the most marked symptom.]

[2] [Almost always retinal glioma occurs in very young children.]

glioma which affords the smallest prospect of success is complete removal of the eyeball, performed before the growth has either perforated the outer tunics, or has made its way into the optic nerve. In many cases it is said to have returned after removal; but in these I doubt whether the conditions above stated were fulfilled. I removed an eye containing a glioma, in December, 1862, from a boy who was then three years old, and who is still living and well, with no appearance of any return of the disease, and another from a child two years old, about fifteen months ago, with the same good result. In a third case the parents removed, and I have been unable to trace them, but there was no return three or four months after the operation. I have mentioned a fourth, which is particularly instructive as regards the question of recurrence, in a communication to the Clinical Society, which is published in the seventh volume of the "Transactions." The history there related is as follows:

"The patient, then a male infant three months old, was brought to the South London Ophthalmic Hospital, and came under the care of Mr. Spencer Watson. Both eyes were absolutely blind, and both retinæ were studded over with white patches of a suspicious aspect. Mr. Watson asked me to see the case, and we advised that one eye should be removed for examination. This was done, the right eye being selected for the purpose; and it was submitted to the committee on morbid growths of the Pathological Society. That committee reported that the patches were gliomata, and we advised the removal of the second eye; but to this, although the child had made a perfectly good recovery from the first operation, the parents would not consent. After the lapse of three years the child was brought to me at St. George's Hospital, the left eye being red and irritable. I found that there had been no recurrence of the disease in the right orbit, but that in the left eye it was just beginning to grow and increase. I strongly urged the immediate removal of the left eye, thinking there was still time to save life, but the parents refused to consent. A month later the eyeball was rapidly enlarging, and causing great pain. I again urged the operation, saying, that if too late to save life, it would at least prevent much misery. The parents again refused; but, three months later, worn out by the child's screams and sleeplessness, they brought him again, and said: 'Do what you think best.' The little patient was much exhausted, and the eyeball had become as large as a small orange; but as I had no certainty that the brain was invaded, I thought I would at least empty the orbit effectually. In order to save blood, I did this by means of the galvanic cautery, and then lined the cavity with chloride of zinc paste. The child bore the operation well, but survived only a few days; and after death a large cancerous mass was found in the left hemisphere of the brain, and the intracranial portion of the left optic nerve was infiltrated by a similar material. Two things were specially noticeable in the autopsy. First, that the application of the actual and potential cautery to the inner side of the

orbital wall had not produced any meningitis or other intracranial lesion. Secondly, that the right optic nerve had wasted into a mere fibrous cord, and that there was no recurrence of cancer in it, or in any of the structures contained in the right orbit. I venture to think it is almost sure, if both eyes had been removed at about the same time, or before the growths took on a state of activity, that the child's life would have been preserved."

Before urging enucleation of the eyeball in the case of a patient of tender years, it is necessary to obtain all possible certainty with regard to the nature of the affection. The cases of glioma are themselves seldom met with, and the cases which simulate them more seldom still; but it has twice happened to me to be deceived in my diagnosis. In the first case the patient was a lad of seventeen,[1] who came to me with an eye which had, he said, been failing in vision for a year or two, had been quite blind for two or three months, and inflamed and painful for a week. The conjunctiva was congested, the globe hard and painful, the pupil dilated. The ophthalmoscope was useless; but focal illumination showed a yellowish mass behind the lens, dimly visible through the turbid aqueous humor. On removal, the whole of the vitreous chamber was found to be occupied by this mass, which was even moulded to the back of the lens, and in which nothing but caseous degeneration could be discovered by the microscope. The second case has been related at page 306; and in this it was found that the yellowish-white deposit within the eye consisted only of a thick layer of inflammatory lymph exudation, lying upon, and completely covering, the posterior surface of the lens.

In neither of the foregoing cases, nor in some of which I have read, and in which the intraocular mass proved after removal to be tuberculous, did the erroneous diagnosis lead to improper treatment. Perhaps, indeed, the diagnosis under such circumstances should be described as incomplete rather than as erroneous. In each instance the eye was irrecoverably destroyed as an organ of vision, and was occupied by a neoplasm, the precise nature of which could not be ascertained prior to removal. It was, therefore, the duty of the surgeon so to act as to secure, even on the worst supposition, the greatest attainable amount of security for the patient; to whom the only ill-result of enucleation, if ill-result it can be called, was the possession of a stump composed of muscles only, on which to place an artificial eye; although a stump containing a remnant of the eyeball, and thus possessing greater mobility and holding power, might have been left with safety. The consequences of leaving a glioma, under the impression that it was either lymph or tubercle, would, of course, be fatal; and it may, therefore, fairly be said that the patient, when certainty is unattainable, should receive the benefit of doubt in the shape of all the protection which art is able to afford, that is to say, by

[1] [A tumor of the fundus of the eye in a patient of this age is almost always a choroidal sarcoma.]

early enucleation of the eyeball. In performing the operation it is necessary to remember that a glioma, even when it has passed through the lamina cribrosa, may not have traversed the whole length of the orbital portion of the optic nerve. For this reason it is desirable, in every instance of suspected malignancy, to divide the nerve at the very apex of the orbit, and not, as would be done otherwise, close to the sclerotic. The division may be effected by an ordinary probe-pointed tenotomy knife, passed along the outer surface of the eyeball till it rests on the nerve, and then carried back, guided by the nerve, to the selected point, when its edge should be turned downwards and the section completed.

The last of the retinal changes that calls for special description is the absorption or disappearance of the pigmented layer of pavement epithelium, which is in immediate juxtaposition with the choroid, and which, until recently, was described as forming part of that membrane. It is impossible to tell whether the epithelium is itself disorganized, or whether it has only lost its contained pigment; for the resulting appearance is but the negative one of transparency, by which the choroidal structure is rendered visible. It has already been stated that in the light eyes of fair people the pavement epithelium which forms the external retinal boundary is not pigmented, or is pigmented only sparingly; so that in such eyes the choroidal vessels can always be seen, and can be readily identified by their almost uniform width, their approximately parallel course, their pinkish color, and their position in a plane manifestly more distant than that of the vessels of the retina. In dark eyes, on the contrary, the pigment of the epithelial layer conceals the choroidal vessels entirely, and gives a uniform brownish-red color to the surface. In persons past the decline of life, in whom the choroid was originally covered in this way, it not unfrequently becomes plainly visible; although certainty that it was once concealed is afforded by the fact that the choroidal stroma is still rich in pigment, which fills the interspaces between the vessels, and produces a general effect of nearly parallel striation behind the retina, the vessels appearing as reddish or orange-colored striæ, the pigmented interspaces as brown striæ. We see this appearance in many eyes about which we are consulted only on account of presbyopia, or of some trivial external disorder, and can hardly look upon it as a morbid change, but perhaps more properly as a senile one. It is often conspicuous in presbyopic eyes, and in the eyes of elderly people suffering from chronic glaucoma or from atrophy; but I am not aware of any facts which enable us to decide upon its precise significance, or to call it anything more than a form of degeneration, which is probably more frequent when there is also some more distinct and recognizable perversion of the ocular nutrition.

It seems proper in this place to notice a condition of the retina which is not a morbid change, although it may easily be mistaken for one. In the normal eye, as already mentioned, the nerve-fibres leave their sheaths at the lamina cribrosa, and only the uncovered

axis-cylinders pass through that structure to form part of the anterior layer of the retina. In a few cases a larger or smaller number of the axis-cylinders carry their sheaths with them; and these sheaths extend to a greater or smaller distance from the margin of the disk, which then appears to be surrounded by an opaque white border, or to send out opaque white processes from certain points of its circumference. The character of the formation is recognizable by the fact that the whiteness buries and conceals the bloodvessels, and that it terminates on the retina in a distinct fibrillation, like the hairs of a brush, never with a sharply defined border. An analogous condition exists naturally in rabbits; but in the human subject it is very uncommon, and in the cases which I have seen it has been confined to one eye only. As a rule it does not impair vision, and is only discovered accidentally; but in the only case I have met with in which the border was complete, the malformation was associated with amblyopia and strabismus. The length of the sheathed portion of the fibres seldom exceeds a single diameter of the optic disk; and the condition, it need hardly be said, is irremediable.

The acute diseases of the choroid have already been mentioned in connection with those of the iris, and they are usually attended by so much turbidity of the media, that the changes which they produce are almost entirely concealed from view. The chronic diseases, which become the subjects of ophthalmoscopic investigation, are various forms of inflammation, usually followed by atrophy, and atrophy which occurs without any obvious antecedent. The inflammations of the choroid may be either diffused generally over the membrane, or disseminated in distinct dots or patches, or confined to some single limited area. They produce, in the first instance, effusion; which is recognized to be choroidal by its position behind the retinal vessels, which pass over the part which it occupies without being distorted or concealed, or in any way altered in aspect except by some new effect of color contrast. As the effusion is absorbed, the affected portion of choroid generally shares its fate, and disappears entirely, leaving behind a white patch, which is the glistening surface of the sclerotic, rendered visible by the removal of the previously intervening vascular tissue. Such patches are commonly surrounded by a border of black pigment, and present a very striking effect. The disseminated form of choroiditis is often congenital, or occurs in early infancy; and children are brought for advice in whom the fundus of the eye retains its natural redness as a general background, but is strewn over with an abundance of small white circular patches, each bordered with black. In the more diffused form the variegation is more universal, and different stages of the disease may frequently be found coexisting; in some places recent effusion; in others partial atrophy of the choroid, with some of its larger vessels remaining, and the sclerotic gleaming through the attenuated network; in others complete atrophy; while an abundant pigmentation is scattered

upon the entire surface, and the vessels of the retina pursue their unbroken course over all. In a great majority[1] of examples, choroiditis is plainly a manifestation of syphilis; and it sometimes spreads by continuity to the retina, and involves that structure in the common ruin; in which case the vessels of the retina would at some period be concealed, and would eventually become atrophied. More frequently it stops short of the destruction of vision, but leaves it much and permanently impaired. The appearances presented are infinitely various, according to the extent of surface invaded, the number and distribution of the patches, the stage of the disease, and the amount of the pigmentation.

As regards any patch in which atrophy is complete, or even far advanced, chronic choroiditis must be looked upon as being wholly beyond the reach of remedies; and we meet with many cases in which the storm has spent its force, in which the mischief is done, and in which nothing remains but to utilize, as carefully and as much as possible, the amount of vision which has been preserved. But whenever ophthalmoscopic examination discovers, in any part of the fundus, a patch of recent effusion, then we may be sure that an insidious morbid process is still going on, and we shall often succeed in stopping it by functional rest of the eyes, careful local depletion by Heurteloup's leech or otherwise, and a well-managed and persevering antisyphilitic treatment. In some of these cases I have given the perchloride of mercury for many consecutive months, not only with much benefit as far as the local malady was concerned, but also with much benefit to the general health and condition of the patient. Even if a syphilitic origin were in any case not only unproven, but unlikely, I should still feel my way with the same kind of treatment, not knowing what else could be substituted for it with advantage, unless some perfectly plain indication were afforded by other symptoms. As in pigmentary retinitis, the true analogues of choroiditis are probably to be found in diseases of the skin; and I cannot deny that choroiditis may be of a non-syphilitic as well as of a syphilitic character. With the latter, however, I am very familiar, while of the former I have seen at most only a few uncertain examples.

The most common form of non-inflammatory atrophy of the choroid is that which is seen in connection with high degrees of myopia. In such cases, when the optic disk is looked at in the inverted image, it appears large, notwithstanding that the effect of myopia is to enlarge the field of the inverted image, and to diminish the size of its details. On closer inspection, it is seen that the apparent magnitude of the disk is due to an irregular band of encircling sclerotic, rendered visible by atrophy of the choroid which was once in front of it. The true nerve-disk will be found as a small circle, looking reddish-gray by contrast with

[1] [We should say, rather, in a great number of cases, although probably not in a majority.]

the white sclerotic, and sometimes placed at the side of the patch of atrophy, which is then crescentic, sometimes in the midst of it. The retinal vessels pass over the white patch undisturbed, and are thrown into strong relief by its whiteness. Sometimes the border of the band most remote from the nerve is pigmented, as in atrophy after inflammation; more often an intermediate zone of partially wasted choroid separates the band from the healthy portion of the membrane. Sometimes the ophthalmoscope shows that the sclerotic behind the atrophy is, as it were, excavated, or formed into a hollow, which, when present, is the expression of a corresponding elevation on the outer surface of the globe. Such changes must have a name, and they have received from many writers the somewhat alarming one of "sclerotico-choroiditis posterior," which implies, I presume, that the sclerotic is supposed to be softened and weakened by inflammation before it projects outwardly, and the choroid before it undergoes wasting. I regard these changes as being the natural and almost purely mechanical results of the tension exerted upon the posterior pole of the eyeball by the internal recti muscles, in producing and maintaining the degree of convergence necessary for binocular vision with unaided myopic eyes; and I think they would scarcely ever be produced if myopic children were constantly made to wear proper spectacles, on principles which will hereafter be laid down, and to keep their work at a distance. Sometimes, I believe, inflammatory changes may supervene upon the muscular tension, and may add to its effects; but I regard the inflammation as a purely secondary phenomenon. When present, and recognizable by infiltration or effusion in the choroid around the wasted band, it should be treated by functional rest, by relaxation of the ciliary muscle by atropine, by local depletion, local cold, and such internal medication as the state of the patient may require; sometimes, doubtless, if there is high tension of the globe and impairment of sight, by iridectomy. But these measures should be regarded as being addressed only to the cure of a temporary condition; and when the inflammation has been subdued and the eyes have been sufficiently rested, the first care of the surgeon should be to provide, by carefully arranged spectacles, for their renewed use under more favorable conditions than before.

Another form of choroidal atrophy, much less common than the foregoing, and of which I have only met with two or three examples, may perhaps be described as interstitial. In the cases to which I refer, the pavement epithelium of the retina was transparent, and the chorio-capillaris had in great part disappeared, leaving the coarser stroma clearly visible. In this stroma many of the vessels had become impervious, and looked like dried threads or cords, and the stroma pigment had also been removed, so that the spaces between the vessels seemed unoccupied. The external layer of stroma pigment remained, concealing the sclerotic; and the retinal vessels were plainly visible. The field of

vision was much contracted, the acuteness of vision much impaired. I am not acquainted with any published description of this state, but a drawing somewhat resembling it is given in Fig. 80, Plate XVII, of *Jäger's Ophthalmoscopic Hand-Atlas.*

There are a few other morbid conditions of the choroid, of little practical importance. Tubercle has been detected in it by several observers, chiefly in cases of acute general tuberculosis. It may, as already stated, be the seat of sarcomatous growths; and it may also be the seat of growths of a benign character. It may, together with the retina, be separated from the sclerotic by effusion; and it is subject to hæmorrhages, which may be detected by their color, and by being distinctly subretinal in position. It may be entirely pigmentless, as in albinoes; and it may be in part congenitally absent. In such cases the gap is usually continuous with a coloboma of the iris, and extends from the latter to the margin of the optic disk.

The disorders mentioned in the present chapter, when they produce extinction of sight, would all have been included, five-and-twenty years ago, under the general term of Amaurosis; that term being used to denote, in the words of Walther's familiar definition, "Jener Zustand, bei welchem der Kranke nichts sieht, aber der Arzt auch nichts." There still remain varieties of impairment or loss of sight which cannot be described in any other manner, although they may generally be attributed, with more or less probability, to some central nerve-lesion which produces no manifest effect upon the eye. Hemiopia, or loss of a lateral half of the field of vision, sometimes occurs as a temporary affection, and is then probably a result of disturbance of the intracranial circulation. Sometimes it occurs in a permanent form, although no changes in the retina or optic nerve can be discovered; and then its causes, unless revealed by other symptoms, can only be matters of conjecture. Persons in whom the fundus of the eye is apparently healthy will sometimes profess to be totally blind—sometimes to have only very defective vision; and such professions, when they are made by those who claim damages on account of some railway or other accident, can hardly be scrutinized with too much care. It would be so irksome and difficult to simulate total blindness that generally, in cases of malingering, the subject is content to have lost the sight of one eye entirely, or that of both partially. In pretended monocular blindness the cheat may generally be discovered by placing a prism, with its edge upwards or downwards, before the avowedly sound eye, when the gaze is directed to a lighted candle three or four yards away. If double vision is thus produced, the imposture is at once revealed. The same test may be applied by letting the person look into a stereoscope, of which the glass corresponding to the avowedly sound eye has previously been blackened inside, so that if he sees anything at all he must see it with the other. When vision is only said to be impaired, the surgeon must form his conclusions chiefly from the coherence and consistency of the narrative; and by ascertaining whether

the degree of impairment is the same however and whenever tested, and whatever may be the distance of the object. In such an investigation a variety of test types will be useful; and if the acuteness of vision at fifty yards is expressed by a different fraction from that of the acuteness at twenty yards, reasonable ground for suspicion will be afforded. It is hardly necessary to say that a practitioner, in investigating such a case, should never betray suspicion unless he can convert it into certainty, and that he should never suffer himself to overlook, in his examination of the eyes, any evidence of central nerve-lesion which may be afforded by other organs.

CHAPTER XIII.

INJURIES OF THE EYE.

ALTHOUGH, from the position of the eyeball with regard to the projecting margin of the orbit, and with regard also to the ocular muscles, the eyelids, and the cilia, it seems to be more sheltered from injury than any other external organ of the body, it is yet, by reason of its exceptional vulnerability, perhaps more liable to be injured than any other. The bruises, cuts, or punctures, which, if they were inflicted elsewhere, would scarcely excite the attention of the recipient, may easily destroy sight when they are inflicted upon the eye; and even particles of dirt, which would rest unnoticed upon any other part of the surface, produce, in the eye, the most lively irritation. The attention of surgeons is daily called to accidents which come under one or other of the foregoing heads; and which derive their whole importance from the locality that is affected by them.

Contusions or blows, inflicted by some substance which can neither cut nor penetrate, may produce rupture of intraocular bloodvessels; rupture of the zonule of Zinn, with dislocation of the lens; rupture of the capsule of the lens; detachment of the retina; rupture of the choroid; separation of a portion of the iris from its ciliary attachment; and stretching or absolute rupture, of the sclerotic; while, in some cases, two or more of these forms of injury may be combined. Rupture of intraocular bloodvessels occurs, of course, as a complication of many other and more serious lesions; but when it occurs alone the blood is generally poured

into the anterior chamber; from whence, if no further harm has been done, it disappears by absorption within a very short period of time. I have frequently seen patients in whom the anterior chamber has been half filled with blood after a blow, and in whom, three or four days later, no vestige of any injury was discoverable. Rupture of the zonule of Zinn, and dislocation of the lens, may be in like manner harmless, if the capsule of the lens remains unbroken, and if the dislocation is into such a position that no pressure is exerted upon the iris. I am acquainted with a patient who has been all his life myopic in a very high degree, who became the subject of cataract in both eyes, who was very nearly blind, and was about to undergo the operation of extraction. While walking one day in the Euston Road he fell down, and the shock ruptured the zonule in one of his eyes, and displaced its opaque lens into the vitreous. On rising to his feet, he discovered that he was cured of his blindness; for his myopia supplied the place of the convex glass usually required after loss of the lens, and he saw the streets and the passengers better than he had ever seen them before. For a long time afterwards he was able, by stooping forwards and shaking his head, to bring back the cataract into the axis of vision; but it subsided again as soon as he resumed the erect posture. The accident had, in fact, performed for him the old operation of "couching," without inflicting any external wound; and, probably for this reason, it was not followed by any of the disasters to which couching so commonly gave rise. When a displaced lens which is not opaque presses upon the iris, or when it passes partially or entirely through the pupil, it must necessarily be highly disturbing to vision, and it is almost sure, at no distant time, to excite inflammatory symptoms which can only be relieved by its removal.

Rupture of the capsule of the crystalline lens, by admitting the aqueous humor to the lenticular substance, causes traumatic cataract, the consideration of which will fall more naturally under the head of similar injury by direct puncture.

Detachment of the retina by concussion I have seen once only, in the case already mentioned in which Von Graefe's treatment by laceration was not followed by any beneficial effect. Of rupture of the choroid, with stretching of the sclerotic, the two following cases are examples:

A boy eight years of age was brought to the South London Ophthalmic Hospital, having sustained a blow on his right eye from a cricket bat a few days previously. The lids must have closed instinctively as the bat approached them, and the chief force of the blow must have been received by the margin of the orbit. The pupil of the injured eye was dilated to the widest possible extent, so that only a narrow ring of iris was visible, and its accommodation was entirely paralyzed. With a lens of + 50, placed in front of a metal diaphragm with a small aperture, normal distant vision was restored; showing the existence of $\frac{1}{50}$th of total hypermetropia; and with a lens of + 12, together with the same

diaphragm "brilliant" type was read easily in the hand. The ophthalmoscope revealed, just below the optic disk, a large crescentic rent in the choroid, through which the white sclerotic was visible. In the other eye, the margin of the choroidal foramen was richly pigmented; and in the affected one the pigment in the same position appeared to have been disturbed, and, as it were, scattered, by the shock. The blood which must have been poured out at the rent had been absorbed; and, with the exceptions mentioned, the fundus was of natural aspect. The extract of Calabar bean produced partial and incomplete contraction of the pupil, the temporal side of the iris remaining unaffected, the nasal side being slightly influenced, and for a short time only. It was manifest that the force of the blow had spent itself on the posterior pole of the eyeball by contre-coup, and that not only was the choroid ruptured, but that the ciliary nerves were also torn through or injured, probably at their point of entrance into the globe. The application of Calabar bean was continued for a considerable time, but without improvement; and a wide zone of choroid around the disk became gradually atrophied, the eye at the same time becoming myopic, but with little impairment of vision. I lost sight of the boy about a year after the injury; but at that time he had $M = \frac{1}{24}$, as tested by the erect ophthalmoscopic image, and his muscle of accommodation was still paralyzed. I inferred that the vascular supply of the posterior pole of the sclerotic must have been diminished by the hurt, and that the consequent impaired nutrition of the membrane allowed it to yield to the compression of the muscles, and so produced the myopia.

A young gentleman, aged about eighteen, consulted me early in 1873, with this history: Three weeks previously he had been following a friend along a narrow path in a plantation, and they were both slashing at the young trees with their walking-sticks. My patient received a blow on his right eye, which gave him such acute pain that he fell to the ground. He believed that the blow was inflicted by a twig which his companion had struck off; and this gentleman felt sure that it had not been inflicted by his walking-stick, both on account of the distance between his friend and himself, and also because no shock had been communicated to his hand. There was no external wound, but the anterior chamber was filled with blood, and vision was for the time abolished. The patient was attended by Dr. Falls, of Bournemouth, who prescribed rest, atropine, and cooling applications. In a few days the blood disappeared and the sight returned, but was said to be still "dim," and it remained in the same condition until I saw the case. The appearance of the eye was quite natural, and the patient, on covering the other eye and looking about the room, said that he could see, but not clearly. He had not tried to read, but on putting test types into his hand I found that the injured eye was myopic, and that he could read "brilliant" type by bringing it within about seven inches of the cornea. A concave lens of $\frac{1}{8}$ removed the dimness, and restored his distant vision to the normal

standard. His left eye was emmetropic; and, as he was a sportsman and a rifle-shot, he was able to say positively that the right eye had not been short-sighted before the blow. The ophthalmoscope discovered a large crescent of visible sclerotic, like the ordinary myopic crescent, only situated at the upper border of the disk instead of laterally; and over this crescent the choroid was absolutely wanting. As far as I could make out, it had been detached by contre-coup, and the sclerotic distinctly bulged backwards at the same time. Fearing that further changes might take place, I noted very carefully the size and position of the appearances, and directed the patient to rest his eyes absolutely for two or three months. In order to carry out this prescription, he took a yacht voyage; and I did not see him again for ten weeks. The conditions were then unchanged, the degree of myopia and the acuteness of vision were the same, the crescent was unaltered in appearance, and there was no indication of choroidal atrophy. I told him he might safely resume studies which the accident had interrupted, and that he might use a concave glass when the right eye was required for distant objects. He was to see me again if vision became at all impaired; and, as he has not done so, I presume that all is well with him.

Such cases as the foregoing are but seldom met with, for the obvious reason that they can only be produced by the application of a nicely graduated amount of force, sufficient to do so much and no more. Complete rupture of the sclerotic is a common consequence of a blow from a fist, and it usually occurs either within or close to the ciliary circle, and between the insertions of the superior and external recti muscles. In this position the rupture is liable to implicate bloodvessels of considerable size, especially the veins contained in Schlemm's canal, and the hæmorrhage from them often fills the anterior chamber, concealing other injuries from view, and, for the time at least, being itself sufficient to destroy vision. A blow which ruptures the sclerotic will generally dislocate the lens, and will often drive it out through the opening; the conjunctiva yielding also in some instances, and the lens being then entirely expelled; while in others it is found beneath the unbroken conjunctiva, either lying in the lips of the wound, or at some little distance from it on the sclerotic. More or less of the iris is under such circumstances forced into the rent, or is sometimes torn away and removed entirely; and more or less of the vitreous body must necessarily follow the lens. When a large part of the contents of the eyeball has been thus expelled, the vessels of the choroid are almost always injured at the same time, and bleeding takes place into the vitreous cavity. The conditions may therefore vary, from a mere subconjunctival tear in the sclerotic to complete disorganization of the globe.

Incised wounds are not very frequent; and are generally produced by fragments of glass, as by the bursting of a bottle. The elasticity of the tunics may prevent any deep penetration by such fragments; and I have seen several instances of a clean cut which

had divided the cornea completely, while both the iris and the crystalline lens had escaped unhurt. In other instances the iris has been cut through and the capsule of the lens opened, so that the external wound was complicated by internal hæmorrhage and by traumatic cataract. An incised wound is generally less destructive than one produced by contusion; but its importance and results must depend entirely upon its magnitude, and upon the structures which it divides.

Punctured wounds are comparatively common; and a large proportion of them occur to children who are engaged in loosening knots, or in undoing bootlaces, with a fork. The fork slips suddenly, and one of its prongs enters the eye. Children's arrows and other projectiles are also responsible for a considerable aggregate of damage of this kind. Among adults, the most frequent sufferers are farm laborers, employed in trimming or binding down hedges, or gamekeepers when passing through thick coppice; in either case the hurt being inflicted by a thorn or by some resilient twig. In the great majority of instances the puncture is in the cornea, and it usually passes into the lens, perforating the iris or not, according as it falls upon the peripheral or the pupillary region of the cornea. A simple puncture of the cornea would be of little moment; but traumatic cataract is always a serious matter, and it becomes more serious still if it is complicated with a wound of the iris, which generally produces an adhesion very quickly, and so hinders the action of atropine upon the pupil.

The most important punctured wounds, however, are those in which the substances that inflicted them have remained within the globe. Pellets of shot, fragments of percussion caps, small pieces of metal or glass, and sometimes even pieces of wood, may become lodged in this manner, and they then seldom fail to excite destructive inflammation.

In dealing with an injury of the eye, as with any of its diseases, the first care of the surgeon should be to ascertain all the ascertainable facts. When an injury has been received, there will generally be a clear history of it, but this rule is by no means without exceptions, especially in comparatively trivial cases. I have seen many instances in which inflammation of an eye was caused by a foreign body, either imbedded in the cornea or lodged beneath the upper lid, but in which this element of the case was neither known to the patient nor discovered by the first surgeon to whom he applied. Whenever the symptoms point to the possibility of such a state of things, the whole of the cornea should be most carefully scrutinized by focal illumination, and the internal surface of the upper lid and its retrotarsal fold should be examined. The removal of foreign bodies from any part of the conjunctiva never presents the smallest difficulty, but with the cornea the case is somewhat different. Particles of glass, coke, or metal, may be firmly imbedded in the corneal tissue; and then, especially if the patient is troublesome or unruly, it may prove by no means easy to extract them. Perhaps the most difficult cases of all are those

in which the point of a thorn has been driven almost through into the anterior chamber, while its shaft has been broken off at, or even a little below, the outer surface of the cornea.

It may be laid down as a general principle that a surgeon who does not often operate upon the eye, and who wishes to remove an imbedded foreign body from the cornea of a sensitive person, will save both time and pain by placing the patient in the recumbent posture, separating the lids with a speculum, and fixing the eye with conjunctival forceps. In the case of children it is better to give an anæsthetic in the first instance. If these precautions are neglected, half the epithelium of the cornea may be scraped off in painful and fruitless attempts, and the foreign body left imbedded after all. With a practiced operator such precautions are [generally] unnecessary; and the patient may be seated in a chair, with the surgeon either seated opposite to him, or standing behind him and receiving his head upon his chest. If the latter position is chosen, an assistant to depress the lower lid will usually be required.

A large number of the foreign bodies most commonly met with in the eye, such as the wing-cases of minute coleopteræ, or the bits of cinder picked up in railway travelling, seldom enter the corneal tissue, but are only adherent to the epithelium. In all such cases they may be dislodged by a touch of any small instrument which is at hand. But when a piece of wood or metal is really imbedded, something more than this is required; and the best instrument that can be used is a very small thin silver spatula, set in an ordinary handle. Cataract needles and all sharp implements are to be avoided, because they scratch the surface at every unsuccessful attempt, and thus occasion much pain. The spatula is free from this objection, and it should be fine enough to be used as a lever or elevator, by being insinuated beneath one corner of the fragment, so as to tilt it out of its bed. When the iris is of dark color, and the fragment small, the latter may be difficult to see, excepting when the light falls upon it at some given angle; and in such cases I generally operate by focal illumination, getting an assistant to control the eyelid and to concentrate the light upon the right spot, while I take a magnifying lens in one hand and the spatula in the other. In this way it is often possible to discover at once which side of the foreign body is most elevated, or most open to attack, and to succeed at the first endeavor. At the South London Ophthalmic Hospital, which is near Messrs. Maudsley & Field's iron works, we see a large number of imbedded fragments. In such establishments there is usually a foreman, or some other person of reputed skill in removing such intruders, who is appealed to in the first instance; so that only those cases come to the hospital which present difficulties that he has found to be insuperable.

In dealing with iron fragments, especially if they have been imbedded for a day or two, the operator may sometimes be deceived as to their presence, and may continue his manipulations

after they are removed. The reason of this is that iron stains the tissue, or leaves a minute portion of brown oxide behind it. Hence, if a fragment has once been fairly touched, the place should be examined with a magnifying glass before a second attempt is made; and it will often be seen that the original appearance is deceptively imitated by a stain at the bottom of the excavation which the substance occupied. This stain is, I believe, always annular: and I find that it is quite unnecessary to attempt to remove it. When the lens shows me a little brown ring round a pellucid centre, I am satisfied that enough has been done, and that any remaining film of oxide will be cast off by the tissues in the course of a few hours.

For the extraction of deeply imbedded and broken thorns, there is no better plan than that suggested, many years ago, by Mr. Dixon. He made an incision with a cutting needle through the periphery of the cornea, introduced a small spatula through the wound, and by its means protected the iris and lens, and supported the thorn from within, whilst it was tilted out by means of a needle used externally by the other hand.

When a fragment has been removed from the cornea, the wound or abrasion which is left behind will often be extremely sensitive, on account of the exposure of the corneal nerves by the loss of the surface epithelium. In order to allay this sensitiveness there is no application so useful as castor oil, a large drop of which may be placed within the lower lid, and suffered to diffuse itself over the eye. The same application will be equally beneficial when the cornea has been accidentally scratched; and its action seems to be essentially mechanical. It may be repeated as often as necessary; and when there is much irritation the castor oil may be made a vehicle for atropine. Four grains of the sulphate may be readily dissolved in an ounce of the oil by the aid of heat; and this compound, whenever atropine is indicated in traumatic cases, is to be preferred to a watery solution.[1]

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[1] [Sulphate of atropia is not soluble in castor oil, even at the temperature of boiling water. At the boiling-point of the oil, at which it begins to undergo decomposition, solution takes place, but the oil acquires somewhat acrid properties. The alkaloid atropia is very soluble in alcohol, and pure alcohol is perfectly miscible with castor oil in all proportions. One grain of atropia requires for its solution about a minim of hot absolute alcohol, and this solution may be mixed, while still hot, with any desired quantity of the oil. The alcohol may then be expelled by exposure of the oily solution for a short time to the temperature of a hot-water bath. Atropia is also readily soluble in ether, and the solution assumes a syrupy or oily consistence, by spontaneous evaporation of the ether. In this syrupy or oily state it may be mixed with castor oil, or with any bland oil, or with lard to form an ointment.

We have made pretty free use of a solution of atropia in castor oil during the past two years, and have thought it especially applicable to cases of painful abrasion of the cornea, attended with spasmodic contraction of the pupil. It seems also to offer a positive advantage over the watery solution of the sulphate, in the fact that it does not readily pass with the tears into the puncta, and so into the nasal passages, and consequently is less liable to give rise to constitutional effects, such as flushing of the skin, dryness of the throat, etc. On this account we often prescribe it (of the strength of four grains to the ounce) in iritis, and it is the form in

If a foreign body has passed through the cornea and entered the anterior chamber, it may either be lying loosely in the chamber, or it may be sticking in the iris, or lodged in the crystalline lens, or it may have passed through the lens into the vitreous, or it may even have passed out of the eye. The two first conditions are very easily dealt with.

A foreign body loose in the anterior chamber should be at once extracted, or should be extracted as soon as the closure of the wound of entrance has permitted the chamber to refill. An incision of sufficient size should be made just within the corneo-scleral junction, as near as possible to where the fragment is lying, so that the latter may either escape with the first outflow of the aqueous humor, or may be carefully taken hold of with forceps and gently withdrawn. If the foreign body is sticking in the iris, no attempt should be made to remove the former alone, but the piece of iris containing the fragment should be itself drawn out, and excised as in ordinary iridectomy. An attempt to remove only the foreign body would be likely to lacerate the iris and to excite inflammation, or to produce prolapsus, which would render excision of the prolapsed portion necessary.

The lodgment of any extraneous substance in the crystalline lens will produce traumatic cataract, by which, in a short time, the intruder may be completely concealed. In young subjects the wounded lens soon becomes diffluent, and a foreign body might then sink to the bottom of the capsule, or might escape from it and fall either into the anterior chamber or behind the iris. In persons past middle life, in whom the central portion of the lens is too firm to be broken down by the contact of the aqueous humor, a foreign body may remain imbedded in the nucleus, and may only be discovered after extraction of the cataract. At St. George's Hospital I lately extracted a cataract from the left eye of a robust farm-laborer, sixty years of age. The hard nucleus, after it had lain for a few minutes upon a table, underwent separation into two hemispheres, like those of a split pea; and further examination revealed the presence of a morsel of iron between them. The patient, on being questioned, said that he had been present at the bursting of a steam-boiler a few weeks before he discovered that the sight of the affected eye had failed; that other persons were much hurt by the explosion, and that he was busy attending to them, and did not know that he himself had been struck. There can be little doubt that the piece of iron must have entered his lens at that time. The case shows, what

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which we generally dispense atropia to out-patients in hospital practice. For use by the patient it may be prescribed of the strength of from one-eighth of a grain to one grain to one drachm of oil; for use by the surgeon himself it may be made as strong as four grains to one drachm: a very small drop, such as may be taken up by the head of a small pin, is sufficient for a single application. In cases of exuberant papillary granulations of the upper lid, with inflamed cornea and excessive flow of tears, we have applied it to the granulated surface of the lid, taking care first to absorb any moisture by a bit of soft linen rag. See *Trans. Am. Oph. Soc.*, 1875, page 255.]

might have been inferred, that a foreign body may remain in the substance of the lens, where there are neither nerves nor bloodvessels, without exciting irritation, or doing any further mischief than to produce opacity; while there is ample experience to prove that no other part of the eye is equally tolerant. A foreign body which passes by the lens, or which passes through it, and in either case finds a lodgment elsewhere in the eye, is almost certain, sooner or later, to set up destructive changes. It is perhaps best that these should appear sooner rather than later; so that the patient may not be lulled into a false security.

Mr. A—— consulted me on the 22d of October, having been struck on the left eye, on the previous day, by a fragment of gunmetal flying from a lathe. He said that he had been conscious of the impact, but had felt no subsequent inconvenience, except that wherever he looked he saw "black balls rolling about." There was scarcely any hyperæmia, little impairment of vision, and no manifest wound. A careful scrutiny of the cornea, by focal illumination and a magnifying lens, discovered a minute black speck, surrounded by a narrow zone of faint haziness, close to the margin, and about the middle of the lower and inner quadrant, the appearances being scarcely discoverable against a background of blue iris No mark or opening could be found in the iris itself; but, on dilating the pupil, the portion of iris corresponding to the mark was less acted upon by atropine than the rest, and there was a spot of opacity, at the corresponding part of the lens, from which three obtuse opaque striæ radiated along the posterior aspect towards the centre, but did not reach it. The ophthalmoscope showed several small masses of coagulum floating in the vitreous; and one of them, spherical, and as large as a medium-sized pin's head, was hanging suspended by two fine filaments, which appeared to be attached near the equator in the upper part of the globe, and which allowed the coagulum to reach nearly to the lower margin of the lens. On a review of these conditions, I inferred that a fine spicule of metal had passed through the cornea, the iris, and the margin of the lens, and had wounded, and perhaps passed through, the ocular tunics in the posterior hemisphere. The black speck in the cornea was manifestly a stain of oil from the lathe; and its minuteness, coupled with the absence of any visible perforation of the iris, afforded sufficient evidence of the minuteness of the projectile. At the same time, the imperfect dilatation of the pupil showed that the iris had been injured; the opacity of the lens gave evidence of a wound in a corresponding position; and the coagula proved that some retinal or choroidal vessel must have been penetrated. The floating coagula did not, of course, admit of any interference; but it was a question whether the suspended coagulum might not inclose the projectile, and whether an attempt should not be made to extract it. It would have been easy, guided by ophthalmoscopic illumination, to thrust a lance-knife through the sclerotic into the vitreous chamber, and to seize the suspended coagulum with forceps and

remove it. Upon full consideration, however, I determined to leave it alone. The coagulum was manifestly far larger than the projectile, and its spherical outline led me to doubt whether it inclosed anything, or was anything more than blood moulded into that shape by the cohesion of its particles. Considering the traumatic cataract, I was unwilling to add a new injury to that which the eye had already sustained. Atropine and rest were prescribed, with an anodyne to be taken in case of pain; and the patient was seen daily. On the 26th the pupil was fully and evenly dilated, the manifest traumatic cataract was stationary, the lens or vitreous slightly cloudy, the coagula were less defined, and there had been a little pain. On the 27th the media were less cloudy, but there was increased conjunctival injection, and a limited iritis at the margin of the pupil in the upper and inner quadrant. With the ophthalmoscope I discovered a small white patch on the retina, above and to the outer side of the optic disk, and in a direct continuation of a line passing through the wounds of the cornea and the lens. In this patch there was a severed retinal vessel, and it was manifestly the part of the fundus which had been struck by the projectile. An evaporating lotion was added to the former treatment. On the 28th the eye was more comfortable, the conjunctival hyperæmia less, the iritis and the cataract stationary, vision equal to $\frac{4}{10}$. Upon the retinal surface, a little below the seat of injury, there was a coagulum, or dark body of irregular outline and doubtful character.

During the next week the eye continued to improve daily. On November 7th my note-book records that the coagula had entirely disappeared, as well as the radiating striæ of cloudiness in the lens, leaving only the actual track of the wound opaque. The rest of the lens and the vitreous were perfectly clear, the iritis had disappeared, the conjunctival congestion was very trifling in amount, and "brilliant" type was easily read, by the aid of a lens to neutralize the paralysis of accommodation produced by the atropine. I ventured to hope that the projectile had passed out of the eye, to lodge harmlessly in the textures of the orbit, and that the case would terminate in recovery. These hopes were doomed to speedy disappointment; for on the 9th of November the injection of the conjunctiva had greatly increased, and was attended by much lacrymation. There was no visible internal change, and it seemed possible that the congestion and the flow of tears might depend upon vaso-motor paralysis from the use of atropine. I therefore directed this drug to be laid aside, and prescribed the instillation, every four hours, of a drop of a solution of nitrate of silver containing two grains to the ounce. On the 11th the conditions were unchanged; the nitrate of silver was abandoned, and atropine and evaporating lotion were used once more. On the 12th there was considerable pain in the eye, with discoloration of the aqueous humor, and I performed paracentesis of the anterior chamber with much temporary relief. On the afternoon of the 13th the pain returned in considerable severity, and continued all night and until

the next morning, when I found the vitreous turbid, and advised and performed enucleation. On dissection of the eyeball, a splinter of gun-metal, about two lines in length, and as slender as a fine needle, was found imbedded among the ciliary processes on the temporal side. It had penetrated the retina and choroid at the point discovered by the ophthalmoscope, and had so nearly cut through the sclerotic as to produce an external projection. From thence it had rebounded, and lodged in the manner described. It was enveloped by a considerable nodule of recently effused lymph, which, in the centre, was already changing into pus; so that, if enucleation had been longer delayed, the patient would have undergone suppuration of the eyeball. It was manifest, from the size and shape of the splinter, that it could not have been contained either in the suspended coagulum or in that seen near the retinal wound; so that any attempt to extract either of these by an operation would not have been productive of advantage.

Among the instances in which the inflammation produced by an imbedded fragment has been long delayed, I may mention one in which a patient came to me with an early stage of insidious iritis. It was part of his history that he had been wounded in the affected eye, fourteen years previously, by a fragment of a percussion cap, and that this fragment was seen lodged in the iris, and was left there in the hope that no harm would arise from its presence. During all the interval which had elapsed, this hope had been fulfilled; but when I saw the case the ophthalmoscope showed a hole in the iris, and rendered it manifest that the morsel of copper had fallen from the place which it had so long occupied. The iritis passed into cyclitis, which imperilled the other eye. I performed enucleation, and found that the tiny piece of metal had fallen down upon the ciliary processes, and had excited the destructive inflammation which supervened. Mr. Soelberg Wells has recorded an instance in which a piece of metal could be seen imbedded in the retina. Since his account was published, and eight years after the injury, this piece also set up inflammation, by which removal of the eye was rendered necessary.

In considering the treatment of any case of injury to the eyeball, the first question which the surgeon has to ask himself is: "Does this menace the safety of the other eye by sympathetic ophthalmia?" It must be remembered that a serious injury can never leave more than imperfect vision, and that sympathetic ophthalmia, although it may be prevented by enucleation, can seldom, if ever, be cured. When, therefore, there is any serious risk of its occurrence, it is obviously improper to seek to save a damaged eye at the probable, or even the possible, cost of the loss also of the sound one; and the patient should from the first be told that his only safety is in enucleation. In the great majority of cases, although not, I think, by any means invariably, sympathetic ophthalmia is ushered in by some feeling of irritation in the uninjured eye, by impairment of its power of accommodation, and by a sense of strain or weariness when it has been used. In dealing

with an intelligent and cultivated patient, therefore, one who is observant of his own symptoms, and not likely to pass beyond the reach of skilled surgical aid, it may often be legitimate to wait and watch the course of events; when, in the case of an uneducated person, or of one returning from a hospital to a country district, it might be expedient to operate without delay. In the former class, however, the influence of expectant attention may be itself injurious; and a person who is always on the watch for changes in the uninjured eye will be liable either to produce them, or to imagine them before they occur. Lastly, whenever an injury is of such a character that enucleation will certainly be necessary, the operation should be performed without delay, and prior to the occurrence of inflammation in the injured organ. In such a case, postponement can have no other effect than to prolong the illness and to add to the sufferings of the patient.

The conditions which almost certainly produce sympathetic ophthalmia are wounds or rents which implicate the ciliary region, and the lodgment of foreign bodies within the eyeball. Those which often produce it, are wounds or rents which render the ciliary nerves adherent in the resulting cicatrices, which are followed by chronic inflammation or obstinate neuralgia, or which ultimately lead to the ossification of exudations in the choroid. I advise enucleation without delay when an eyeball is broken up and disorganized by a blow, or by a puncture from a coarse instrument; when the ciliary region is either ruptured or cut through; when any foreign body is lodged within the eye; when, at any period after an accident, there is abiding tenderness of any part of the ciliary region, with liability to conjunctival flushing when the eye is lightly touched for the purpose of examination; or when there is any sense of bony hardness conveyed by palpation of the deeper parts of the injured globe. In some of these conditions sight would necessarily be extinct, in others it might be remaining in some degree; but, on the grounds already stated, this would have little bearing on the course to be pursued. A seriously damaged eye can never be worth preserving at the cost of actual risk to its fellow.

When a foreign body is lodged within the eye, it may sometimes be within reach of removal, and its removal may leave possibilities of recovery. The question then will be whether it is necessarily the only one which has found entrance; and in a case in which many particles have been flying about it will not be safe to assume the correctness of an affirmative reply without good reason. I was once summoned to a northern town to see a gentleman who had been shot in the left eye whilst grouse driving. The wound was in the lower part of the cornea, and the pellet had probably wounded both iris and lens; but there was too much blood in the anterior chamber to allow of this point being made clear. For the same reason, no view of the fundus could be obtained. There was little or no pain, and distinct perception of light. The surgeons in attendance differed in opinion about the

:ase; one of them advising enucleation, the other thinking that the blood would be absorbed, that the pellet might not have remained within the eye; that even if it had done so, it might be n the anterior chamber or in the lens, and that after a time iridectomy, and extraction of the traumatic cataract, might leave a useful eye. I maintained that the risks of delay were greater than the probable advantages, and gave my voice for the immediate removal of the injured organ. On making a section of it, we found not one pellet of shot only, but two, lying a little apart from each other upon the retina. If by any chance one of these pellets had been extracted without enucleation, the surgeons might very well have been lulled into a false security, and might have left the patient with an eye containing a certain source of future mischief.

The operation of enucleation is very simple, and, when the outer tunics are unbroken, is very easy of performance. The patient being placed in the usual recumbent posture, an anæsthetic being administered, and the lids separated by a speculum, the surgeon pinches up and divides the conjunctiva all round the margin of the cornea, and dissects it back from the sclerotic, together with the subconjunctival tissue, as far as the insertion of the muscles. From this stage he may proceed either by the common or by the Vienna method. In the former, he passes a strabismus hook under each of the four recti tendons in succession, and cuts it through with scissors at its attachment to the sclerotic. He then makes the eyeball start forward by pressure with his fingers, so as to put the optic nerve upon the stretch; and, taking a pair of blunt-pointed scissors, curved on the flat, he causes them to glide closed along the sclerotic from the temporal side until they touch the nerve, when they are opened, and made to include and to sever it. The eyeball will then almost drop out, and requires only two or three strokes of the scissors, close to the sclerotic, to divide the attachments of the oblique muscles, and any remaining shreds of connective tissue. In the Vienna method, the operator cuts the tendon of the external rectus upon the hook, leaving a portion about half a line in length attached to the sclerotic. He then seizes this portion with strong forceps, rolls the globe inwards, divides the optic nerve from the temporal side, and cuts the remaining muscular and connective tissue attachments as he lifts the globe out of the orbit. This method is the more rapid of the two, but care is required in order not to take away too much of the external rectus tendon. An error in this respect would diminish the subsequent mobility of the stump in an outward direction.

When the eyeball has been ruptured, and its coats are empty and flaccid, the operator must dissect out the sclerotic as carefully as he can, using hook and scissors for the muscles, and drawing the remains forward with forceps in order to divide the nerve. The proceeding is often difficult, especially if the conjunctiva and orbital tissues are inflamed, infiltrated with blood, or swollen; but by perseverance it will generally be possible to remove everything, and to leave conditions favorable for healing. Some surgeons unite

the wound in the conjunctiva by sutures; but this proceeding does not seem to me to be attended by any advantage. I have often practiced it, and have more often omitted it; and the resulting stumps have been equally serviceable in either case. However enucleation is performed, the cavity should immediately be firmly plugged with sponge, which should be secured by a bandage, and left undisturbed for three or four hours, or until hæmorrhage from the divided vessels has ceased. If this precaution is neglected, blood will find its way into the cellular tissue of the cheek and eyelids, producing extensive ecchymosis, which will require two or three weeks for its removal. When the sponge is removed, a single moist compress will be all the dressing required; and in a week or ten days the patient may be provided with a glass scale,[1] to be worn for a time as the precursor of a well-fitted artificial eye. The latter must not be expected to move so well on a stump formed of muscles alone, as on that which has been described when speaking of the operation for staphyloma; but, even on the muscles alone, it will sometimes deceive persons whom it would be hardly fair to characterize as superficial observers.

It is necessary to bear in mind that any undue delay in the application of an artificial eye is apt to permit the occurrence of contraction of the cavity, even such that it may prevent a proper match for the other eye from being worn eventually. Moreover, until either a scale or an artificial eye is inserted, the lacrymal secretion cannot find its way into the canaliculi, but must accumulate between the lids and overflow them from time to time. The conjunctiva covering the stump will permanently yield a rather free mucous or muco-purulent secretion, which it is often desirable to diminish by an astringent.[2] For this purpose I usually prescribe a lotion of acetate of lead, of about five grains to the ounce of water; and direct a pellet of wool moistened with it to be placed between the lids during the night, or even to be placed in the concavity of the artificial eye during the daytime. Sometimes the conjunctiva becomes swollen into prominent folds; and it is then desirable to leave the eye out for a day or two, and to touch the prominences lightly with diluted nitrate of silver. Lastly, whatever care is taken of it, the external surface of an artificial eye becomes roughened, in course of time, by the chemical action of the tears; and the rough surface irritates the lining membrane of the lids, and produces an obstinate form of conjunctivitis, which commonly leads to contraction. It is, therefore, necessary that an artificial eye should be thrown aside as soon as the polish of its surface is destroyed; and a year is gen-

[1] [It is often good practice to insert an artificial eye as early as the fourth day, letting the patient wear it for an hour twice in the day, and longer as soon as it can be so worn without discomfort.]

[2] [A fungoid growth, pedunculated in form and of a soft cellular structure, often appears in the centre of the stump formed by the coalescence of the recti muscles, and may give rise to prolonged suppuration. It is easily removed, and the suppuration cured, by snipping it off with scissors.]

erally about the longest period during which it can be worn with safety.

If we turn now to the injuries which do not call for the removal of the eye, or which permit a period of observation before that operation is required, we have first to consider the solutions of continuity of the external tunic. A wound of the conjunctiva and sclerotic, behind the ciliary region, will generally divide also the choroid and retina, and will be rendered conspicuous by some protrusion of vitreous. Under such circumstances it is best to cut off the protrusion, and to unite the lips of the wound by a single point of fine suture, which should be inserted by means of a small, sharp, semicircular needle, held in suitable forceps The eye should then be closed, and covered by a compressive bandage, which may be occasionally laid aside in favor of cold compresses if there should be either heat, or pain, or swelling of the lids. After thirty-six hours, the suture may usually be cut and removed, and the further treatment will be little more than the enforcement of functional rest until the consolidation of the cicatrix is complete. In incisions through the cornea, which do not implicate the iris or the lens, the object is to procure healing without adhesion of the iris; and for this purpose, if the wound is at all extensive, a suture may sometimes be used with advantage. The experience of Dr. Williams of Boston, after cataract extraction, and that of many other surgeons, after excision of the apex of conical cornea, has shown that this membrane is very tolerant of sutures, and that the coaptation which they produce is favorable to speedy union. If a wound of the cornea is in the central portion, the iris may be kept altogether away from it by atropine; and if it is in the marginal portion the iris may be rendered tense, and less likely to prolapse into the cicatrix, by the contraction of the pupil produced by Calabar bean, which may be applied in the same manner as atropine, either in a gelatine wafer or as a solution of the extract. If a suture is inserted, care must be taken to use a fine and sharp needle, so that the cornea may not be bruised during its introduction; and care must also be taken, in tying the suture, that no fold of iris is caught between the edges of the wound. If prolapsus of the iris has already occurred, this, if small and recent, may sometimes be reduced by friction through the closed lids, or by the extremity of a probe, or, according to its position, by the action of atropine or of Calabar bean. More frequently, however, the prolapsus will be either strangulated in the opening or already adherent by effused lymph; and then, as a rule, it should be removed, although if the injury is three or four days old, and healing is proceeding quietly, the adhesion may be left for subsequent treatment. In order to remove a strangulated or adherent prolapsus it is generally necessary to enlarge the opening, and this may be done by a Weber's canaliculus knife (Fig. 62, page 201), the beak of which may be insinuated between the prolapsus and the wound, and carried on until a portion of the cutting edge is within the anterior chamber, when the edge may be turned forwards and made to

divide the cornea from within outwards. The prolapsed iris should then be seized, and excised, as in iridectomy, with sufficient freedom to prevent any subsequent prolapsus from taking place. After excision of the iris it is unnecessary to apply a suture; and to do so might entail risk of wounding the crystalline lens. Participation of the iris in the original injury would make no difference in the treatment to be pursued, although it would obscure the case by causing hæmorrhage into the anterior chamber, and would increase the probability of inflammatory complications.

When the lens itself is wounded, or the anterior capsule divided, the lens tissue always loses its transparency by the action of the aqueous humor, and traumatic cataract is produced. The gravity of this accident will depend very much upon the extent of the wound, and very much upon the age and constitutional state of the patient. In young children, say under five years of age, the result, according to my experience, is unfavorable in the majority of cases;[1] and the shock to the nutrition is apt to produce chronic inflammation leading to wasting of the globe. In patients of unsound constitution, or who have passed the middle period of life, the prognosis is decidedly unfavorable, and violent and destructive inflammation is often excited by the pressure of the displaced and swollen lens matter upon the iris. In healthy persons from childhood to middle life, a favorable result may in most cases be anticipated. The principles of treatment are to dilate the pupil as fully as possible with atropine, to enforce absolute quiet and rest of the eyes, to apply leeches and cold compresses to subdue irritation, and to remove the lens substance if it threatens to produce inflammation, or if, from the age of the patient, the nucleus is probably too hard to be absorbed. In a young patient, when the lens matter is all diffluent, it may be removed by suction, in the manner previously described; with an iridectomy if the pupil is anywhere adherent or if it will not dilate freely; without an iridectomy if atropine produces its full effect. If the lens matter is still coherent, or probably hard, it may be removed with a scoop (such as that used by Pagenstecher for the extraction of the lens in its capsule), after a large iridectomy, which should generally be made in a direction downwards and inwards. When the bulk of the broken lens matter has been removed, the subsequent inflammation will usually be amenable to treatment. It is generally necessary, in order to avoid excessive manipulation, to leave some small portion of the lens to be absorbed; and there will nearly always be a certain degree of subsequent iritis, which, even at the best, may leave the pupil obstructed by false membranes, which will eventually require laceration or removal.

When the capsule of the lens is ruptured by a blow, without any external solution of continuity, or when under similar circum-

[1] [It has been our experience that wounds of the lens are not especially destructive in young children, if faithfully treated. The intentional wounding of the lens capsule in the operation for cataract by discission is certainly not especially dangerous in infants.]

stances the lens is dislocated in its unbroken capsule, the eye is generally very tolerant of the injury. Such a case differs from traumatic cataract with corneal wound, as a simple fracture differs from a compound one. If the capsule is ruptured, the lens substance will protrude into the anterior chamber, and will usually be absorbed with little trouble, even in persons who are no longer young. Whilst this page is being written, I have under observation at St. George's Hospital a laundress, fifty years of age, the lens capsule of whose left eye has been ruptured by a blow from a flat-iron. A few days afterwards she came, saying that the sight of the eye was lost. The lens had become opaque, and a mass of cortical substance was projecting into the anterior chamber. Although the pupil was of natural diameter, and the iris in contact with the projection, there was not only no iritis, but no congestion of the conjunctiva. Atropine was ordered, and has since been used, and absorption of the traumatic cataract is proceeding without a sign of irritation. As the cortex disappears, it may probably reveal a nucleus too hard for absorption; but, until then, there can be no need to interfere. When the lens is dislocated in its unbroken capsule it will sometimes produce inflammation by pressure upon the iris or ciliary body: and it will nearly always cause such disturbance and irregularity of refraction as to interfere very greatly with sight. In the former case, in order to avoid worse consequences, it must be removed, not only without delay, but even in anticipation of actual inflammatory action, as soon as any pericorneal vascularity gives warning of impending mischief. In the latter case it may be removed in order to restore vision; but if the other eye is useful it is generally better left alone. The operation will almost necessarily be attended by some loss of vitreous; and the lens, in such cases, has a tendency to recede and disappear as the vitreous advances. The patient should be brought very fully under the influence of ether, so that the ocular muscles may be passive; and a large incision should be made, either with a linear or a lance knife, through that part of the corneo-scleral junction from which the margin of the displaced lens will be most accessible. The iris should be drawn out and cut away to the full length of the incision; and then Taylor's vectis (Fig. 86, page 331), or a Pagenstecher's spoon, should be passed well under the lens with a quick and decided movement, and carried completely to its further margin. The lens, well engaged in the traction instrument, must then be lifted up towards the cornea and slowly withdrawn, great care being taken to keep the point of the traction instrument more elevated than its heel, and also to contend against any tendency to slipping of the lens by means of careful counter pressure, made with broad fixation forceps, at a point opposite to the centre of the incision. Even with the greatest care, the lens will escape in some instances, and will be left in the eye. If this should happen, another attempt at extraction may be made if the lens remains visible; but if it has sunk out of sight it is better to close the eye and to repeat the operation at some future time if circumstances

should favor it. If the wound heals well, the lens will generally reappear, and the iridectomy will sometimes remove any tendency to inflammation. It is hardly possible to search in the vitreous cavity for that which is lost to sight, without great risk of inflicting irrecoverable injury upon the retina or the ciliary processes. Some operators prefer a hook to a spoon even for the first attempt at extraction; and Mr. Streatfeild recommends the employment of two hooks at once. Of this method I have no personal experience.

The issue of cases in which the lens is driven out of the eye will chiefly depend, other things being equal, upon whether the rupture is in or in front of the ciliary region, and also, in a great degree, upon whether the conjunctiva is also torn. If the rupture is in the ciliary region, nothing but the patient's refusal to submit restrains me from enucleation; and in two cases this refusal has enabled me to watch, without responsibility for its occurrence, the commencement and the course of sympathetic ophthalmia. If the rupture is in front of the ciliary region, in the corneo-scleral junction, and if the conjunctiva has yielded, it is only necessary to cut off any protruding iris and vitreous humor, and to treat the injury as if it were a surgical one. It is astonishing how well these cases will do. I know two patients, from one of whom a crystalline lens was extracted by a fist, from the other by a crowbar. In one, a large segment of iris is altogether missing, in the other a similar segment is incorporated in the cicatrix. They both have vision quite equal to the average result obtained after the removal of senile cataract.

When the conjunctiva remains entire, its entirety must be carefully preserved; and no consideration of prolapsed iris should induce the surgeon to convert the simple fracture into a compound one. But, when the internal wound is healed, the lens often forms an unsightly and uncomfortable prominence which interferes with the proper closure of the eyelids. The principle of treatment is then the same as in the case of a loose cartilage, which has been pressed out of a joint into external cellular tissue through a subcutaneous incision. When the internal incision is healed, the outer covering may be divided, and the foreign body removed. The conjunctiva, for this purpose, should be pinched up over the projection with forceps, and cut to the proper extent with fine scissors. It is generally necessary to snip through a few filaments of connective tissue, before the lens can be tilted out of its bed.

A class of injuries totally distinct from those hitherto considered arises from conditions which produce destruction of the conjunctiva, and of the epithelium, or even of the substance, of the cornea. Such results are witnessed after the introduction into the conjunctival sac of hot metal, hot liquids, or corrosive substances. Hot metal is the agent most commonly concerned in their production; and hence they are familiar to the surgeons to great foundries and similar establishments. Away from these, they are mostly due to accidental scalding, to accidents with

quicklime, or to vitriol-throwing as a criminal offence. When either hot metal or quicklime has been the agent, it is not uncommon to find considerable pieces lodged beneath the lids.

In all cases of this class, it is necessary at once to evert the lids, and thoroughly to explore and cleanse every part of the conjunctival surface. Where a chemical corrosive has been at work, the mind naturally turns towards a chemical antidote, but, before this could be procured, it would generally be possible to remove every trace of the noxious agent by a syringe and warm water. Sometimes the corneal tissue will be found completely disorganized; and then the case is beyond the reach of art; for the cicatrices of burns or corrosions are always densely and permanently opaque. When only the epithelium is affected, a restoration of transparency may be hoped for; and, if the epithelium has anywhere escaped injury, the preservation of vision will be tolerably sure, unless it should be practically destroyed by the alteration of the corneal curvature produced by the cicatrization of injured portions. After a complete cleansing, there is nothing to be done but to apply atropinized oil to the conjunctiva, cold compresses to the closed lids, to relieve pain by anodynes, and to await the event. The tissue will be thrown off where it has been destroyed, and such repair as circumstances will permit must be promoted by judicious general and local treatment.

In consequence of the structure and mode of closure of the lids, the great majority of these injuries affect only the lower sac of the conjunctiva, and the lower portion of the cornea; and we commonly find some destruction of the surface of the latter, and of the ocular and palpebral conjunctiva beneath it. When this is so and the conjunctival sloughs are cast off, the opposed denuded surfaces unite during the process of healing, and produce the condition called symblepharon, which has already been mentioned at page 193. Hitherto, this union has scarcely ever been prevented. The uniting cicatricial tissue becomes continuous with the corneal cicatrix, feeds the latter with its bloodvessels, and renders it thick and fleshy. Even although only the lower half of the cornea may be affected, the patient is seldom able to see over the upper margin of the cicatrix, and practical blindness is the result. Symblepharon is moreover a source of great misery, by constantly checking the eye in its endeavors to move together with its fellow, by preventing the passage of tears to the inner canthus, and thus causing their overflow, and by producing sensations of strain and dragging which are always present. Until recently it was considered to be irremediable; and many plans to prevent the union, or to prevent its reunion when divided, were tried and failed. Plates of metal, glass, and ivory, were in vain inserted between the opposed surfaces; they were constantly extruded by the steadily progressive healing from below. I once endeavored to prevent reunion by a double fold of animal membrane fixed well down by silver sutures which passed out upon the cheek, but no success rewarded me. It was reserved for Mr. T. Pridgin Teale,

who receives from the Yorkshire ironworks large numbers of such cases, to discover the method of treating them; and his discovery, like most others which are good for anything, has no higher merit than its simplicity. He separated the adherent lid from the eyeball by careful dissection; and then covered the raw surface of the eyeball by conjunctiva transplanted from above the cornea, and brought down, sometimes in two flaps, sometimes as an undivided band adherent at both extremities. The transplanted conjunctiva adhered readily in its new position; the raw surface of the lower lid had no longer a raw surface opposed to it; and the gap under the upper lid was soon filled up by a new formation hardly distinguishable from the old. The details of the operation do not admit of any general description, because they must necessarily vary with the position and extent of the surface to be covered, so that each case requires to be made a subject of individual study. Sometimes the first operation will not effect all that is desired; but, even then, it generally leaves comparatively little to be done, and places ultimate success beyond question. The immediate effect of Mr. Teale's procedure, the liberation of the eyeball by the cure of the symblepharon, was alone a great boon to the patients; but the ultimate result has been in every case the thinning out, and sometimes the absolute disappearance, of the corneal cicatrix. About two years ago I operated upon a little boy, then three years old, in whom the lower lid was adherent over the whole of the lower third of the cornea; and now his eyeball is not only perfectly free, but the transparency of his cornea is almost entirely restored, and promises, at no distant time, to be restored completely. At the International Ophthalmological Congress, in 1872, Mr. Teale exhibited several patients upon whom he had operated with admirable success; and he and Von Graefe at present stand alone, among the ophthalmic surgeons of the nineteenth century, as the two men who have found conditions reputed to be incurable, and who have brought these conditions under the absolute dominion of their art.

I am not aware that any attempt has been made, on the principle of Mr. Teale's method, to prevent the occurrence of symblepharon by applying the transplanted conjunctiva to the original granulating surface of the eyeball; but its adhesion would probably be less certain than upon a surface prepared for it by dissection. There can probably be no doubt that very much might be done to prevent symblepharon by M. Reverdin's plan of grafting. A few grafts from the conjunctiva of the same or of the other eye would be easily applied and retained, and the success of even one of them would at least diminish the extent of adhesion. It would be very important to form a barrier of grafts between the cornea and the surface of the eyeball below it; so that the lid might in any case be prevented from uniting with a corneal cicatrix.

In lacerated or incised wounds of the eyeball, the eyelids also are sometimes implicated, and may be cut or torn in various ways. When there is no loss of tissue, such wounds should be carefully

cleansed, brought together, and united by as many points of fine suture as may be necessary to maintain apposition.[1] The best sutures for this purpose are formed of the finest platinum wire, as fine as hair, introduced by means of beading-needles; and if such wire is not at hand human hair will make an excellent substitute, save for the disadvantage that its elasticity renders it difficult to tie. The eyelids are very richly supplied with blood, and possess great reparative power, so that portions hanging even by a shred should be carefully preserved and replaced. In any case which seems likely to require enucleation of the eyeball, it is very desirable that wounds of the lids should be healed before that operation is performed, since otherwise cicatricial bands may unite the wound of the lid with the stump, and may place a permanent difficulty in the way of wearing an artificial eye. When there is actual loss of substance of the eyelid, an endeavor should always be made to supply the deficiency either by skin-grafting or by the transplantation of a flap from some neighboring part, since any deformity of the lid will expose the globe to some degree of injury. I have seen some very ugly results produced by grafting upon the eyelids the coarser skin of the arm, the new portion being much more prominent than the old, and obviously of different character and texture. The tiny morsels required for grafting may always be taken from the lid of the other eye, or even from the injured lid itself, without fear that any contraction or alteration of shape will be produced.

In all injuries of the eye, of whatever nature, as in all forms of disease, the practitioner often finds himself opposed by physiological (or pathological) conditions, of which he can give no more definite account than that they destroy the fruit of his labors. They come, only too frequently, within the scope of his experience, but they can hardly be said to lie within the boundaries of his knowledge. An injury, which in one eye scarcely excites reaction, may lead to the swift destruction of another; and conditions which have been tolerated for a time may suddenly become the causes of complete disorganization. We attribute these differences to depraved blood, or to perverted innervation; and the phrases are little more than counters, employed to disguise our lack of genuine coin. At best they are only hypotheses, something postulated to explain what seems otherwise inexplicable; and yet it is certain that the differences to which they refer may be at the very root of surgical success or failure, and hence that they deserve, above all others, to be made the subjects of careful investigation. In the case recorded at page 407, for example, it was only when the wounds inflicted by the metallic splinter had healed, when the effused blood had been absorbed, and the irritation consequent upon the wounds and the hæmorrhage had subsided, that the irritation consequent upon the lodgment of the foreign body com-

[1] [It is often necessary to include the whole thickness of the lid in the sutures; sometimes a suture may be inserted upon the conjunctival surface as well as through the skin. We prefer very fine silk to wire or any other material for sutures.]

menced; and it was remarkable how immediately this irritation was reflected along vaso-motor nerves to the outside of the eye, and declared itself by renewed distension of the vessels of the conjunctiva. In many severe diseases, it is the chief part of the function of the physician to watch for and to obviate "the tendency to death;" and so, in many injuries of the eye, it is the chief part of the function of the surgeon to obviate the tendency to unhealthy inflammation. In wounds in other parts of the body we see this tendency appear and disappear, with little effect upon the ultimate result, or with little effect of any kind save loss of time in the progress towards recovery. The ulcer which was healing yesterday may be flabby and unhealthy to-morrow, or the cut which promised to unite by the first intention may be found suppurating when its coverings are removed. In neither case would such changes occasion anxiety; but, when analogous changes occur in the eye, they are, however fleeting, generally sufficiently prolonged to be fatal to its usefulness. The causes of such changes will be understood, as a matter of scientific knowledge, only after experiments and observations for which the eye furnishes no proper field; and for the prosecution of which ophthalmologists must be dependent upon those whose work is among less important structures. I think it would be quite possible, in the treatment of slight superficial wounds, to vary the conditions of patients in many ways, and probably with instructive results; but all that we can at present do towards securing healthy reparative action in the eye is purely empirical. We can exclude great variations of temperature, and can secure an abundant supply of atmospheric air. We can diminish excessive excitement of the nervous system, and can take care that this system is invigorated by sleep and not unduly irritated by pain. We can inquire into the state of the excretions, and can do something to relieve the body from undue accumulation of waste products, and to regulate the quantity and quality of food. We can stimulate the processes of repair by the administration of so-called tonic medicines, selecting them by the light of the results which we have previously seen them produce. When we have done all this, we may nevertheless find that our reasonable hopes are frustrated. We are forced to recognize the existence of more things than are dreamt of in our philosophy, and to admit that time and chance happeneth to all.

There is one question of considerable importance which it is necessary to mention, and about which there are wide differences of opinion. It is: "Has mercury any influence upon the amount or character of the inflammation which follows injury?" I think not; but many for whom I entertain high respect think otherwise. The gentleman, whose case is mentioned at page 407, consulted another surgeon a day or two after receiving the injury, and brought from him a message to me, which, as it was delivered, recommended the use of mercury or of quinine. The patient was a man of great intelligence, and said, "What do you think of these suggestions?" I could only reply that I used mercury

freely, and fully recognized its value in inflammations of diathetic or of apparently spontaneous origin; but that my experience did not support the belief that it would increase the tolerance of the tissues for the presence of a foreign substance. I should not give it because there was a bullet in the tibia, neither should I give it because there was a fragment of metal in the eye. With regard to the quinine, I thought it prudent to hold such an agent in reserve, in case the powers of the system should begin to flag, rather than to administer it when they were apparently in full vigor. The reasoning was at least good enough to satisfy the patient; but I have since often asked myself whether it was sound. It is at least certain that neither mercury nor quinine, even if capable of altering the course of events in this particular case, could have altered them to any advantage; and that for the simple reason that their influence, however beneficial, would not have been permanent. A piece of metal in the ciliary region would have been an ever-present source of danger, not only to the eye containing it, but also to the other; and perhaps the very worst thing which could have happened would have been for the foreign body to be tolerated until this danger was forgotten. There is therefore nothing to regret as far as this particular eye is concerned; but the suggestion serves to give point to the inquiry whether the use of mercury would have contributed to toleration, and whether, with a fragment lodged in a less important locality, its use might be advantageous. I can only say that I have no experience which inclines me to such a belief; but that I am ready to learn from those who have facts to which they can appeal. In the way of admission upon the point I cannot at present go beyond the Newtonian phrase, "It may be so;" and in this attitude of mind I am unwilling to use a formidable weapon in the dark, killing with it, according to the time worn saying of D'Alembert, it may be the disease, it may be the patient. The prescriber should work, I think, upon a basis either of highly probable hypothesis or of trustworthy empirical observation; and, when both are wanting, his anxiety to do good should not be suffered to obscure the plain duty of withholding his hand from doing harm.

CHAPTER XIV.

SQUINT, AND AFFECTIONS OF THE OCULAR MUSCLES.

WHILE the muscles which move the eyeballs retain their natural powers and natural harmony, the two eyes are always directed to the same point in space. If the point is near, the optic axes are convergent; if it is remote, they are approximately parallel, with some slight inclination to convergence; and this without reference to the direction in which they may be turned, whether upwards, downwards, forwards, or laterally. The maintenance of this relation is in great measure dependent upon a sensational stimulus of the strongest kind; for as soon as it is interrupted, as soon as the optic axes are directed to two points instead of to the same point, the two eyes can no longer unite their respective images, and double vision is produced; than which there are few things more worrying and distressing to a patient. It is especially distressing when the departure from the natural direction is so slight as to be scarcely perceptible to another person; for then each of the two images falls upon a sensitive part of the retina, so that each possesses strength and clearness, and the two are projected to positions so near together that it becomes difficult readily to distinguish the true from the false, and difficult therefore to direct any bodily movement with accuracy. When the deviation is extreme, the false image falls upon a peripheral part of the retina, is comparatively faint and feeble, and is soon altogether neglected or forgotten. The instinctive desire for single vision may be gratified, therefore, either by the maintenance of muscular harmony, or by a very wide departure from it; and the tendency of the muscles, if they are unable to overcome a small deviation, is to permit its increase until it is no longer a source of inconvenience. The permanent forms of deviation are commonly included in the generic term strabismus, or squint; the temporary forms are more usually described as spasm of the muscle which produces the deviation, or as paralysis of that which permits it to occur.

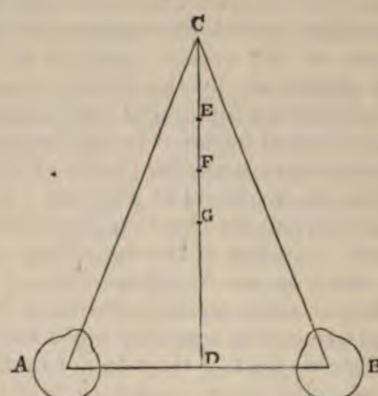
The most typical permanent form is the common convergent squint which commences in early childhood, and which is a result of efforts to overcome hypermetropia by the muscle of accommodation.

Hypermetropia has already been described as a condition in which the eyeball is too flat, or too short from front to back; the retina being within the focal distance of the crystalline lens, and, therefore, receiving from it nothing but blurred and imperfect images. In order to obtain clear images, it is necessary that the

focal length of the crystalline lens should be diminished; and this diminution is brought about by contraction of the ciliary muscle, which renders the crystalline lens optically stronger by increasing the curvature of its anterior surface. This effort, however (the effort of accommodation), is required, in normally constituted eyes, only for near objects; which also require a high degree of convergence in order that both the optic axes may be directed to them. Hence there is a natural co-ordination between the two muscular actions of accommodation and convergence, a co-ordination that probably has its seat in the central ganglia of the third pair of nerves, and is not disturbed by the faulty shape of the eyeball which constitutes hypermetropia, and which is a mere imperfect development of an external organ. In the hypermetropic eye, the accommodation is necessary even for vision of distant objects, for which no convergence is required at all; but the co-ordination of the central ganglia overpowers the visual requirement, and the internal recti contract together with the ciliary muscles. As the latter are always more or less in action during waking hours, it follows that the former also receive more than their due share of nerve influence, and are called upon for more than their due share of functional activity; so that, if they do not undergo active hypertrophy, they at least come to preponderate over the other external muscles, and their state of frequent contraction produces a tendency to something like structural shortening. The effect of this is that the axes of the eyeballs, in a state of perfect rest, are no longer approximately parallel, but distinctly and equally convergent; the internal recti muscles governing their position, somewhat in the way in which the flexors of the limbs generally overcome the extensors during sleep. At the age of two or three years, when the child begins to look attentively at near objects, he requires a still greater effort of accommodation in order to see them clearly; and in making this effort he makes a corresponding effort of convergenee, with the result that, as his eyes start from a position of acquired convergence instead of from parallelism, their total convergence becomes greater than is necessary, and they are both directed to a point nearer than the object, so that double vision is produced. In order to see clearly, and to avoid the double images, the child then renders one eye less convergent, so that it may be directed to the object; and, as the two axes have become combined in a relation of convergence, instead of in their original relation of parallelism, it follows that, when one of them turns outward to fix the object, the other turns inward in a greater degree than before. In Fig. 101, A and B represent a pair of hypermetropic eyes, which, by the development and constant action of their internal recti, have departed from their original state of parallelism when at rest, and are actually combined in a state of convergence; their axes, A C, B C, subtending equal angles with the imaginary line D C, drawn from the root of the nose into space. If now the attention is directed to an object at E, a nerve stimulus is applied which would have brought the optic axes from parallelism

to the positions A E, B E, but which, as the axes start from a state of convergence, actually brings them to the positions A F, B F. The child then receives two images of E, neither of them on the yellow spot, and neither of them distinct. He is unable, by the action of both external recti, to overpower the stronger internal recti, so as

FIG. 101.



to direct both his eyes to the proper point, and he cannot relax the internal recti without at the same time relaxing his accommodation, which he is bound to maintain. But he is able, by the action of one external rectus, to turn both eyes together, as if they were structurally united. If he fixes the eye B upon the point E, the eye A moves together with B, turning inwards as B turns outwards, and directing its axis along the course A G. If he fixes the eye A upon the point E, the eye B moves together with A, turning inwards as A turns outwards, and directing its axis along the course B G. It follows that one eye looks at the point E, and sees it clearly, while the other looks at the point G, or towards the nose, and squints. It receives a false image of the point E, but upon so peripheral a portion of retina that the double vision occasions no inconvenience, and is neglected by the attention until it ceases to be an object of consciousness.

In some children, in whom the refraction and the acuteness of vision are alike in the two eyes, and in whom the external recti are of equal strength, it is a matter of accident which eye will be directed towards the object, and which towards the nose, and the squint is then said to be alternating. Sometimes one eye squints, sometimes the other. But this equality of sight and of muscular power is not common; and the majority of children can direct one eye more readily than the other, or can see with it more clearly. When this is the case, the employment of the best eye becomes instinctive; it is always directed to the object, and the other always squints. The squint is then said to be fixed; and under such cir-

cumstances the vision of the squinting eye will usually undergo a steadily progressive deterioration.

In a case of fixed squint, after the lapse of a certain time, it is conceivable that the internal rectus muscle of the squinting eye may undergo structural shortening, and that its external rectus may undergo atrophy from disuse, so that the faulty position would become permanently established. Practically, however, this does not occur; and it is probable that the two eyes always return to equal convergence during sleep, as they usually do under the influence of an anæsthetic. At any rate, if the working eye is closed or covered, the squinting eye can then be made to fix an object correctly, just as if the squint were still alternating, and with the natural result that the working eye will deviate inwards, behind its covering, to the same extent that the squinting eye deviated before. The deviation of the working eye is called the secondary squint, and it is observed in the following manner. The surgeon holds up any conspicuous small object before the patient, in the median line, about a foot or fifteen inches from the eyes, and directs the patient to look at it steadily. The working eye will of course be directed towards the object, and the squinting eye towards the nose. The surgeon then covers with his hand the working eye in such a way as to shut out its view of the object, but so that, himself standing before a child or a seated adult, he can look down from above, and can watch the movements of the working eye over the upper margin of his hand. The squinting eye will at once emerge from its retirement and fix the object, while the working eye takes up the squint. As soon as the covering hand is removed, the former conditions are restored. The working eye instantly resumes its fixation, and the squinting eye its squint.

When the secondary deviation of the working eye is equal in its extent to the ordinary deviation of the squinting eye, we have evidence that the squint is not caused by abnormal muscular weakness. For example, a fixed convergent squint of the right eye might be produced by paralysis of its external rectus muscle, so that the internal rectus had no antagonist, and rolled the cornea inwards. If the paralysis were complete, the squinting eye would make no effort to fix the object when the working eye was covered, because the former would have no power of abduction or outward rotation at all. If the external rectus were not paralyzed, but only weakened, the squinting eye would turn outwards when the working eye was covered, with an effort more or less feeble; and the working eye would turn inwards in a greater degree. The reason of the unequal extent of the two movements is that the central nerve-ganglia of the right external and of the left internal rectus are in intimate relation, for the purpose of directing both eyes to the right; and the muscles would receive motor impulses of the same strength at the same moment. The weakened muscle would respond feebly, the healthy muscle naturally; and the eye which was moved by the healthy muscle would make a

larger excursion than that which was moved by the feeble muscle. Hence it is only when the secondary deviation is equal to the primary one that we have to deal with uncomplicated strabismus; and whenever the squinting eye has lost its power of fixation, or when its movement for that purpose is attended by a still larger movement of its covered fellow, the squint is either caused or complicated by paralysis, in the former case complete, in the latter incomplete, of the physiological antagonist of the muscle by which the deviation is produced.

When the sight of both eyes is good, and the squint is uncomplicated by paralysis, it is always curable, not only coarsely, and so as to correct a manifest deformity, but perfectly, so [far] as to restore harmony of position and movement under all circumstances, by a well-planned and skilfully performed operation or operations. As long as the squint is alternating, the operation may be postponed without injury; but as soon as the squint becomes fixed, unnecessary delay will probably involve impairment of the sight of the squinting eye; and this, besides being a loss to the patient, will interfere with the excellence of the result. In very young children, when a fixed squint renders an operation necessary, it is often best to be content with a somewhat coarse correction, and to leave the final operation for a subsequent period of life. The surgeon may always say that the result is absolutely under his control; but that in order to attain perfection he must be permitted to operate twice, or even thrice, if it should be necessary.

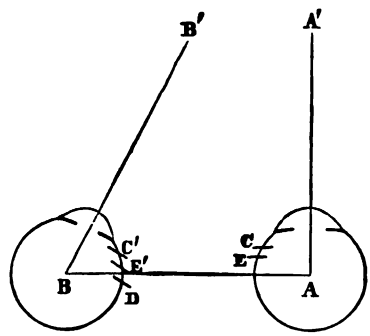
The immediate object of each single squint operation is to separate the tendon of the internal rectus muscle from its attachment to the sclerotic, with the least possible disturbance of the surrounding parts, so that the muscle may form a new attachment somewhat posterior to its original one, and thus may produce, by the same amount of contraction, a smaller degree of convergence than previously. The final object of all the operations which may be necessary is to place the optic axis in a position of approximate parallelism, or with only the normal slight inclination to convergence when the eyes are in a state of complete functional rest;[1] and to do this without any impairment of the normal power of volitional convergence, which should be left perfectly available for directing the eyes to near objects, and for maintaining this direction as long as it may be required.

If we reflect that squint is always a binocular affection, it becomes manifest that a perfect result can seldom be obtained by an operation on one eye only. If the degree of deviation is not large, such an operation may indeed produce parallelism when the eyes are at rest, and may correct a conspicuous deformity; but it can only do so at the cost of producing a permanent difference of convergence power between the two, so that a common motor impulse would affect them differently, and the eye operated upon would lag behind the other during every effort to direct both to some

[1] [See quotation from Donders on page 78.]

near point. Fig. 102 represents a pair of eyes, A, B, in the ordinary condition of fixed squint. At rest, they would be somewhat convergent; but the working eye, A, is habitually directed forward, for visual purposes, along the line A A′, and the whole convergence is manifested by the squinting eye, B, which is habitually directed inwards, along the line B B′; these two lines always inclosing an

FIG. 102.



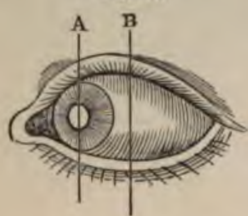
angle of the same magnitude. The internal recti muscles of the two eyes are inserted into the sclerotic at the points C C′. Let it be supposed that an operation upon the eye B, which put back its internal rectus to a new attachment at D, would overcome the habitual convergence, and would allow the line of direction B B′ to become parallel to the line of direction A A′. When the eyes were directed forwards, the squint would be cured; but the internal rectus muscle of the eye A would be left in a position of advantage, with its excessive strength undiminished, while the internal rectus muscle of the eye B would be weakened by being placed in a position of great disadvantage. When any attempt was made to fix both eyes on a near object, the same central motor impulse would produce different results upon the two, and the eye B would either lag behind its fellow, and appear to squint outwardly in relation to it, or its muscle would become tired and strained by being called upon for a greater exertion than its fellow. The proper operation is to divide the correction equally [or nearly so] between the two eyes, putting back the two muscles to the points of attachment E E′. By doing this we not only obtain parallelism when the eyes are at rest; but we leave them with equal and sufficient convergence power, and replace them, so to speak, in their natural condition, from which they had been compelled to deviate by the acquired hypertrophy of their internal recti muscles.

The magnitude of a squint is commonly expressed by the distance between a vertical line, bisecting the palpebral opening (B, Fig. 103),[1] and a second vertical line, bisecting the pupil of the

[1] [The line B, is rather the vertical line bisecting the pupil of the squinting eye when it is in the position of looking directly forwards.]

squinting eye when the working eye is directed forwards (A, Fig. 103). A variety of instruments have been made for measuring this magnitude, and for expressing it in lines or millimetres; and the supposed uses of such instruments have chiefly rested upon the belief that a squint of less than a certain measure might be cured by an operation on one eye only, but that a larger squint would always require an operation upon both. For the mere production of parallelism when at rest, this is quite true; for although it is possible, by severing the internal rectus very freely from its ocular attachments, to allow it to fall back to a considerable extent, and to restore the parallelism of eyes in which the original squint was very large, yet such operations are attended by certain obvious disadvantages. The least of these is that the caruncle and plica semilunaris are dragged backwards by the retracting muscle, and that the natural aspect of the eye at the inner canthus is destroyed. Another, more serious, is that the diminished volitional convergence power of the eye operated upon produces double vision of near objects, and that to obviate this the weakened internal rectus is gradually overpowered by its antagonist, and a divergent squint is produced. The operation for squint, although modern, was suggested and performed long before the cause of the affection was understood, and before the existence of hypermetropia was recognized. In those days surgeons had no other notion than to divide the tendon of a contracted muscle, and they often did this with a very free hand, using a grooved director and a bistoury, or other clumsy instruments, and dividing the same tendon a second time for the removal of any convergence which was left after the first operation. A few people who have been thus treated are still living; and they usually exhibit a deformity far worse than that of which they were relieved. Even if they have escaped divergent squint, the disappearance of the caruncle, and the restricted mobility and undue prominence of the eye operated upon, cause it to bear much resemblance to an artificial one. The prominence is usually most manifest on the inner side, and depends upon the destruction of the natural harmony between the internal rectus and its antagonist, so that the original seat of attachment of the former is tilted forwards by the action of the latter.

Fig. 103.

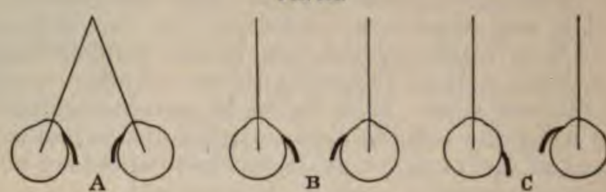


Even in a squint of moderate dimensions, in which a result satisfactory to a careless observer may be obtained by a single operation, the retraction of the caruncle is apt to constitute a disfigurement. A few years ago Mr. Liebreich, after much study of the anatomy of the recti muscles, but with an apparent disregard of the etiology and nature of squint, and of the objects which should be aimed at in any operation for its relief, announced that retraction of the caruncle might be prevented by completely dissecting the conjunctiva from the subjacent parts; and that when this

was done a very large deviation might be cured by operating on one eye only. It seems obvious that if we sever all the connections between the conjunctiva and the muscle, the latter will be at liberty to retract in any degree without dragging the former after it; and so far Mr. Liebreich is right. But the object of a scientific surgeon, in operating upon squint, is to restore the natural harmony, balance, and perfect co-ordination, between the internal and external recti muscles; and this object can very seldom be attained by any monocular operation. Mr. Liebreich's method not only fails to attain it, but even, in the manner already explained, produces a huge inequality in the volitional convergence power of the two eyes. In so far as it prevents retraction, and thus takes away the manifest and superficial objection to a large displacement of one muscle only, it deprives patients of what was in some degree a security against the eventual and more subtle injury which must necessarily follow a correction which has been thus produced. Patients operated upon in Mr. Liebreich's manner may pass muster when they are looking out into space; but a pair of eyes, one of which has a strong, and the other a weak internal rectus, will never work pleasantly together in the daily employments of life. The only method of perfectly curing squint, even when it is of moderate degree, is to divide the correction, as nearly as may be possible, equally between the two eyes, which really, though not apparently, participate equally [or nearly equally] in the deviation; and to sever the attachments of the tendons to the sclerotic with the least possible severance of any of the neighboring tissues, and with the least possible disturbance of their natural relations. After some practice it becomes possible, by using the scissors with greater or less freedom, to graduate approximately the distance to which the severed tendon will be retracted; and the retraction may also be diminished, when necessary, by the careful employment of sutures. In a large squint, it is often admissible to operate on both eyes at once; but with a squint which is not large there is always, when this is done, a risk of over-correction. In such cases, and in all cases until the surgeon has gained considerable experience, it is best to divide first the tendon of the squinting eye only, and to leave that of the working eye until the former has recovered, and until its internal rectus has regained considerable power. By this proceeding the deviation should be only diminished; and it will often happen that the conditions which originally determined upon which eye the squint should fall will continue in force. and that the diminished squint will be of the same eye as before, thus giving to an uninstructed person the idea that something further should be done to it. The something further, however, must be done to the eye which is straight; and it is often a great mystery to patients and their friends how an operation upon this can correct the remaining deviation of its fellow. When once the essentially binocular character of squint is clearly understood, the principle on which it should be treated is seen to be of great simplicity. In

Fig. 104 the eyes at A are shown as squinting eyes restored to equal convergence by an anæsthetic, the dark lines representing the internal recti muscles. At B the same eyes are shown as they are left when cured by a double operation, with both muscles set a little farther back than before; and at C they are shown as left parallel after a single operation, with one internal rectus set

FIG. 104.



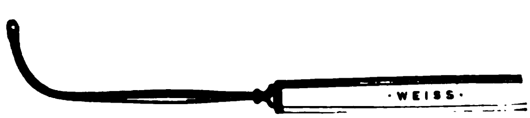
greatly back, and the other in its original position. Considering that the eyes should work together, it is hardly possible to doubt which of the latter conditions should be preferred.

[The author very properly condemns the practice of attempting to correct any very great degree of deviation by an operation upon the deviating eye only, but we believe that he is in error in supposing that Liebreich has ever advocated any such course in the treatment of the ordinary forms of strabismus. It is a well-established fact that the correction attained by a simple tenotomy of one rectus internus does not ordinarily exceed two or two and a half lines, and that the effect of a double tenotomy (*i. e.*, upon the recti interni of the two eyes), does not usually exceed five lines (see page 434). In deviations of five lines or more even a double tenotomy may therefore be insufficient, and a second operation may have to be performed upon one eye, or possibly upon both. It was chiefly to obviate this necessity of operating a second time upon the same eye, and also to avoid the disfigurement resulting from the retraction of the caruncle, that Liebreich devised the method which is now known by his name. In very slight degrees of strabismus, probably no surgeon would think it good practice to try to divide the correction between the two eyes, and this is probably true, also, of all grades in which a single careful tenotomy suffices to restore parallelism of the visual axes. In higher grades of deviation it is the well-established rule always to operate upon both eyes, either simultaneously or with an interval of several weeks between them, rather than to try to throw the whole correction into one operation, and so necessarily leave a marked inequality in the motions of the two eyes. In some cases of long-neglected squint, however, in which the deviating eye is often practically worthless, the patient may desire to be relieved from conspicuous deformity, and yet may be unwilling to submit to an operation involving even the slightest risk to the good eye. In such a case there is no longer any possibility of restoring the eyes to anything approaching a normal condition, but only of re-

moving, more or less perfectly, a very unpleasant deformity, and an operation upon the deviating eye by Liebreich's method may afford a satisfactory cosmetic result when the effect of an ordinary tenotomy upon one eye would be altogether insignificant. Liebreich has advocated a tenotomy by his method upon the squinting eye alone, in a few cases of complicated and exceptional character, but never, so far as we are aware, as a general practice in operating for ordinary convergent strabismus. See Liebreich, in *Archiv für Ophthalmologie*, XII, II, pp. 298–307.]

For the true principle on which a squint operation should be performed, as far as its mechanical features are concerned, we are indebted to Mr. Critchett. Before his time it was customary to divide not only the tendon, but all the structures superficial to it, leaving a wound which was often troublesome, and which was almost always followed by a conspicuous scar. Mr. Critchett suggested that, as other tendons were divided subcutaneously, the tendon of the rectus muscle should be divided subconjunctivally; and this suggestion was the first great step towards the improvement of the surgery of strabismus. The operation of Von Graefe is, I venture to think, inferior to that of Mr. Critchett in every respect;[1] and that of Mr. Liebreich has already been sufficiently referred to. In the actual manipulation, the work of almost every surgeon will be found to have some feature peculiar to itself, and various modifications have been made in instruments which still remain essentially unchanged. It is necessary to have a speculum to separate the lids, a pair of forceps, a hook, a pair of scissors, and a fine suture needle threaded with very thin silk. The hook which I use is of the precise form and size shown in Fig. 105, and

FIG. 105.



is somewhat flattened. It carries an eye at its extremity, but this is not required for ordinary cases, and its uses will be described hereafter. My scissors are pointed, and curved on the flat, as shown at Fig. 51 B, page 160, but with blades more slender than those of the figure. It is thought by some that there is danger of running sharp points through the sclerotic; and perhaps it may be safer for a learner to perform his early operations with blunt ones.

The patient being in the recumbent posture, and fully under the influence of ether,[2] I take my position on his right hand side. The

[1] [The superiority claimed for Mr. Critchett's operation is probably more imaginary than real. Our preference is, on the whole, for the method of Arlt, which differs but little from that of Von Graefe.]

[2] [In operating by Arlt's method we generally dispense with an anæsthetic.]

speculum being inserted, I either roll the eye outwards, or wait until sufficient abduction occurs spontaneously, and then pinch up a vertical fold of conjunctiva and subconjunctival tissue with forceps. Fine straight forceps, as fine as iris forceps, are the best for this purpose. They should be applied nearly at the spot where the inner vertical and the lower horizontal tangents to the cornea would intersect each other, and should pinch up everything which is superficial to the sclerotic. The scissors should then cut through the fold to its very base, close to the forceps and below them, so as to make a clean horizontal incision right down to the sclerotic. The forceps should retain their hold for the mofnent, and the scissors should just make sure that the sclerotic is exposed. Then, exchanging the scissors for the hook, and fixing the eye by still retaining hold with the forceps, the operator places the extremity of the hook on the sclerotic, runs it a little down, to be sure of getting below the tendon, well back, to be sure of getting behind it, and then upwards and forwards in a bold curve, the extremity of the hook never losing touch of the surface of the eyeball. When this manœuvre is properly executed, the extremity of the hook shows under the conjunctiva above the upper margin of the tendon, and the curved part of the hook is completely concealed from view by the body of the tendon, and is checked by it from advancing to the corneal margin. If the whole of the hook can be seen through the conjunctiva, or if it can be pulled up to the corneal margin, it is not under the tendon at all, and another sweep must be made. When the hook is rightly placed, the operator shifts it into his left hand, and takes up the scissors with his right. He makes steady traction with the hook towards the outer canthus, passing his left arm for this purpose across the face of the patient when operating upon the left eye. Holding the scissors very slightly open, their curve corresponding to that of the hook, he introduces them into the wound, and passes the point of the lower blade under the tendon, in contact with the convexity of the hook, which serves as a director, while the point of the upper blade is insinuated between the conjunctiva and the tendon, just making its own track through the subconjunctival connective tissue. When the scissor blades include a third or a fourth of the width of the tendon, they may be closed, then opened again and pushed on in the same way for another snip, and so on, until the whole of the tendon is divided; when the hook, no longer held back against the traction of the operator, will at once break through the connective tissue and advance to the corneal margin. The operation is then completed.

An unpracticed surgeon, after getting his hook under the tendon, will sometimes lose his hold, even before he applies the scissors. This is of no great consequence, as the hook has only to be reapplied; but it does not impress bystanders favorably, and the introduction of an instrument twice, when once ought to be sufficient, produces unnecessary disturbance of the tissues. The way to avoid the accident is by steady traction, especially when

changing the hook from the right hand to the left. If it is fairly introduced in the first instance, and then kept tight, it will never slip until the tendon is divided. If it is not fairly introduced, that is, if its extremity does not emerge above the upper margin of the tendon, it will come forward as soon as the portion actually in front of it is divided; and hence, as division of the whole width is essential to success, the learner should always make a final sweep of the hook to insure that none of the upper fibres have escaped. This precaution, however, should be laid aside as soon as practice has given confidence; and the custom of rummaging about with instruments under the divided conjunctiva is one of which I need only say that it is more honored in the breach than in the observance.

In a general way, the external wound requires no treatment, and from its horizontal direction its edges fall at once into apposition. But if it was originally a little large, or if any accidental vertical cut is made in the conjunctiva during the operation, a suture may be passed through this membrane only, and either removed on the following day or suffered to make its way out. A suture should also be applied if the cut edge of the tendon is exposed in any part of the wound, as otherwise a fleshy prominence is apt to spring up at such a place, and to be a source of temporary disfigurement. Such a prominence in time becomes pedunculated by the pressure of the margins of the lids.[1] It may then be snipped off close to the conjunctiva, and the cut surface may be touched with nitrate of silver, after which all trace of the growth will disappear.

The amount of bleeding after a squint operation is very variable, depending partly on the skill and promptitude of the surgeon, partly on the vascular state of the patient, and partly on the action of the anæsthetic. In hospital practice the operations are performed on out-patients, who, notwithstanding all injunctions to the contrary, often come with a quantity of undigested food in their stomachs, and vomit before they return to consciousness. The consequent straining produces more bleeding than would otherwise occur, and much of the blood remains in the interstices of the connective tissue, and is only slowly absorbed, producing an unsightly appearance for a time. If in any case it were very desirable to prevent this disfigurement, the causes of vomiting should be guarded against with especial care, compresses wrung out of iced water should be applied to the closed lids after the operation until all bleeding had ceased, and a spirit lotion afterwards in order to promote the absorption of any blood which had actually been left among the tissues.

I have already said that a certain graduation of effect may be produced by the greater or less freedom with which the scissors are employed; and the difference between the results thus attain-

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[1] **[Fungoid growths from the exposed fibrous tissue, whether tendon or sclera, assume a pedunculated form in cases where there is no possibility of pressure from the margins of the lids, as for instance, after enucleation of the eyeball.]**

able is simply due to this, that when the tendon is completely divided, the extent to which its extremity will be drawn back by retraction of the muscle will be governed by the degree in which it is set free from surrounding parts, and especially from the capsule of Tenon and from the adjoining connective tissue above and below. It will depend, in other words, on the extent to which the scissors are used downwards, before the insertion of the hook, and upwards after the tendon is divided; and also, in some degree, upon the way in which the hook is introduced and manœuvred. The strength and character of the attachments depend greatly on age, sex, temperament, and general bodily conformation; but it may be said as a rule that not more than two lines of retraction will be obtained by the bare division of the tendon; and that as much as four or five lines of retraction may be obtained by free severance of the tendon from its surroundings. It is better, however, to do too little than too much; and on the system of double operation a little more than two lines of retraction will almost always be enough for each eye, as a squint which measures five lines is one of large dimensions. When the first operation is completed and the patient is restored to consciousness, fully two-thirds of the total squint should be cured; but this effect will be somewhat diminished when the cut tendon has regained its hold upon the eye. No after-treatment is necessary, except to give the eyes functional rest for a few days (I generally direct that there should be little or no reading, and for a child no lessons, for a week); and in about a month, if the eye operated on possesses, when the other is closed, a free range of mobility in all directions, showing that its internal rectus is once more securely attached, the operation on the other eye may be performed.

In this second operation, especially in small squints, there is a manifestly greater risk of doing too much, and of producing divergence, than in the first; and the division of the tendon should be made with a corresponding degree of care. If it should be apparent, at the time of the operation, or upon restoration to consciousness, that the effect produced is too great, it may be diminished by a horizontal suture, passed through the conjunctiva near the corneal margin, carried pretty deeply through the subconjunctival tissues towards the caruncle, and so tied as to bring forward the end of the tendon. It must be remembered that the immediate will always be greater than the ultimate effect; on account of the function of the internal rectus being suspended for the time, or at least only exercised indirectly, through the intermediation of some part of the capsule of Tenon.

It is manifestly impossible, on the living eyes, either to obtain the precise degree of retraction which is needed, or to divide it with diagrammatic equality between the two. Here, however, the requirements of function come to the aid of the imperfections of art. The surgeon leaves, let us say, half a line of residual convergent squint, or he produces half a line of divergent squint, by over correction; and in either case the defect will [often] be over-

come by the efforts of the antagonist muscles to remove the resulting diplopia. When a patient, after the second operation, complains at first of double images, lying very near together, it may be confidently predicted that they will soon disappear, and that the ultimate result will be entirely satisfactory. If the images are somewhat far apart, and if the distance between them should increase, it will be manifest that either too much or not enough has been accomplished. In the former case there would be crossed images and divergence of the optic axes; in the latter, homonymous images and some remaining convergence. In the former case it might be necessary to perform the operation which will be described in speaking of divergent squint; in the latter it might be necessary to divide once more the internal rectus of the squinting eye. A few cases have been recorded in which the tendon of this muscle has been found to have a second attachment posterior to the first, and in which this second attachment required division before the desired effect could be produced.

In cases in which the vision of the squinting eye is very imperfect, so that the annoyance caused by double images would not be experienced, perfect harmony of movement can rarely be attained for want of sensational guidance. In these cases the only object of the surgeon is to convert a conspicuous deformity into a comparatively trifling one, and he may sometimes do this by operating to the fullest extent on one eye only, using Mr. Liebreich's plan of undercutting the caruncle and the plica semilunaris, by dissecting with scissors between the conjunctiva and the tissues beneath, so as to avoid marked retraction of the former. This should not be done unless the defective vision is irremediable; for sometimes, when it depends only upon disuse as a consequence of the deviation, much good may be effected by compelling the squinting eye to read daily with the help of a strong magnifier, while the working eye is closed; after which if sufficient improvement is produced, the ordinary operation may eventually be successful.

When fixed convergent strabismus is found to be dependent upon, or at least associated with, paralysis or weakness of the external rectus muscle, it is manifest that little good can be hoped for from division of the internal rectus, unless the strength of its antagonist can be restored; and, on the other hand, it is often useless to treat the weakened muscle as long as its wasted fibres are stretched, and hindered in their feeble attempts at contraction, by the shortening of the other. When paralytic cases are recent, they must be treated without operation, on the general principles presently to be laid down; but we meet with a few instances in which the paralysis seems to be only an effect of a condition which has passed away. I have now had a sufficient number of cases of this kind under my care to feel sure that they may always be cured if the paralyzed muscle retains its electric contractility, so that it will respond either to the continuous or to the induced current. If, after two or three trials, I find that electric contractility is wholly lost, I abandon the case as hopeless; but if it is retained, I

first divide the contracted muscle, and then apply a suitable current to the other daily, for as long a time as may be required. The following case, which is quoted, with some slight alterations, from the fifth volume of the *Transactions of the Clinical Society* is a fair type of the class to which it belongs:

S. G., a married woman, 33 years of age, came to St. George's Hospital on the 16th of May, 1871, asking to be cured of squint. She was of healthy aspect, and presented no appearance or history of either syphilitic infection or intracranial disorder. She said that her eyes were straight until shortly before the preceding Christmas, when her husband took her by the throat and shook her; but the squint did not appear for a fortnight after this domestic incident, and the connection between the two was by no means clear. When she first applied, her right cornea occupied a central position in the palpebral fissure; but the left cornea was so much rolled inwards as to be scarcely visible. When standing directly in front of her, only the external third of the left cornea could be seen, and the pupil had quite passed out of view. The movements of the right eye were free and unrestrained, but the left was fixed in the state of inversion above described, and could not be rolled outwards even when the right eye was closed. The best efforts of the patient produced no greater effect than a scarcely perceptible quivering

After having given iodide of potassium for some weeks without avail, I determined to treat the malady as a local one. On July the 19th I thoroughly divided the tendon of the left internal rectus at its insertion into the sclerotic; and noted at the time that the shortened muscle was felt as a tense and firmly resisting band. A day or two afterwards, when the conjunctival wound had healed, I found the eye very much in its old position, to which it had probably been guided back by the internal fibres of the superior and inferior recti. I then commenced localized faradization of the external rectus with the primary current of a Stöhrer's battery,[1] and under its influence the muscle soon began to contract decidedly, and to draw the eye outwards during the actual period of the application. Steady increase of strength was gained, until at last, although the ordinary or resting position of the eye remained almost unaltered, the patient became able, by a strong effort, to roll it quite to the middle of its orbital fissure when the other eye was covered, producing, of course, a very large secondary squint in doing so. Beyond this point we made no advance; and therefore, on the 22d of November, I performed a second operation, by dividing the internal recti tendons of both eyes. The patient was exhibited to the members of the Clinical Society on the 12th of January, 1872; and at that time her eyes were both perfectly central, and their natural mobility in all directions was entirely

[1] [The better instruments of Drescher and of the Galvano-Faradic Company of New York, and the "pocket electro-medical apparatus" of Gaiffe, give the "primary" or "extra" current, as well as the secondary or induced current.]

restored, even that of the left eye in the direction of its once paralyzed external rectus.

I was first induced to apply this method of treatment, in 1867, in consequence of the very defective results which were usually yielded by the plan then laid down in text-books of ophthalmic surgery; that is to say, by division of the contracted muscle, together with shortening, bringing forward, or readjustment of the paralyzed antagonist. It is evident that such an operation has no tendency to cure the paralysis: that it can give no power of motion to the paralyzed muscle; and that if, by merely shortening this, it drags the eye into the middle line, the patient will have double vision of all objects on the paralyzed side, while the manifest deformity will be very likely to recur.

For the application of the localized faradization, Messrs. Weiss made me a small pair of rheophores, each insulated in a handle common to both, so that they can be used by one hand, leaving the other free to control the eyelids. The terminations of these rheophores, hardly larger than lacrymal probes, were covered by thin leather to retain moisture, and were applied directly upon the conjunctiva over the affected muscle. The extremities could be set more or less asunder at pleasure, and the current was transmitted every day, for three or four periods of a minute each, with short intervals between them. A very small amount of battery power was employed; and it was sometimes found necessary to separate the lids by a speculum.[1]

The divergent form of strabismus is much less common than the convergent, and is produced either by weakness (insufficiency) of the internal recti muscles, or by the loss of guidance incidental to defective vision. The insufficiency of the internal recti is mostly artificial, produced by excessive or unskilful setting back for the cure of convergent squint; for congenital insufficiency, although it may interfere with the use of the eyes at short ranges, seldom produces [a very high grade of] actual divergence. When the vision of one eye is defective in a high degree, that eye is no longer guided to correct fixation by a sensational stimulus; and then, under the influence of forces the nature of which is not very clear, it often becomes so divergent[2] as to produce considerable disfigurement. A divergent squint proclaims that its owner has something the matter with his eyes, and is often a bar to obtaining employment; so that, from concern for personal appearance, or even for more weighty reasons, patients are usually very solicitous to be relieved of it. For this purpose [if the divergence is very great] it is never sufficient to divide one or both of the external recti muscles; but it is also necessary to shorten the internal rec-

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[1] **[The constant galvanic current, using from four to twelve or more cells as practiced by Benedikt, is often a very efficacious remedy in paralysis of one or more of the ocular muscles (see page 195). The current from a series of from three to twelve cells, interrupted by a mechanical rheotome, and applied directly to the affected muscle, will sometimes produce contraction when the interrupted current of the induction apparatus fails.]**

[2] **[In some cases convergent.]**

tus of the squinting eye, or to advance its attachment, or both. When the divergent squint is the result of over-correction of a convergent one, it may be sufficient to bring forward the muscle; but, when it is the result of defective vision, it is generally necessary also to shorten the tendon.[1] Several operations for these purposes have been contrived by different surgeons; but most of them are open to the objection that they mutilate the conjunctiva, and thus produce some dragging or contraction towards the inner canthus, generally attended by manifest deformity. In my own hands (or in the cases operated upon by others which have fallen under my observation) none of these methods have been entirely satisfactory in their results; and hence I have been led to devise what I think is an improvement upon them. In doing so I was much aided by some suggestions taken from a case which has been described by Dr. Agnew of New York; and experience has since shown me how to overcome certain difficulties of detail. I can now feel certain that a failure will only leave the divergence uncorrected, without entailing any new or additional defect; and all my cases have hitherto been successful. The operation requires speculum, forceps, a strasbismus hook with an eye at its extremity, strabismus scissors, slender semicircular needles and a needle-holder, fine and stout silk, and a few pieces of the finest silkworm gut such as is employed by anglers.

The patient being recumbent and fully etherized, and the speculum introduced, the first step is to divide the conjunctiva and subconjunctival tissue of the squinting eye, on the horizontal meridian, from near the margin of the cornea to the caruncle, so as completely to expose the middle line of the tendon of the internal rectus. By a little dissection with the scissors, the tendon is then entirely separated from the tissues in front of it; and the strabismus hook, armed with fine silk, is introduced into the wound, carried from above downwards and made to pass under the [lower border of the] tendon, and then to project beyond its upper margin. The operator next seizes the upper lip of the wound with forceps, and lifts it over the extremity of the hook, and he then seizes the silk and retains it while the hook is withdrawn, so as to leave under the tendon a ligature, which is used to draw through a somewhat stouter one. This second ligature is firmly tied round the tendon near the sclerotic, but not so near as to be in danger of slipping when the tendon is carefully cut from the sclerotic with scissors. This being done, the external rectus should next be divided beneath the conjunctiva precisely as the internal rectus is divided in operating for convergent squint. The operator then draws forward the internal rectus by the ligature, and passes two gut sutures through it from without inwards, as far back as he may consider necessary, one near to the superior, the other near to the inferior margin. The needle carrying the

[1] [Whether the tendon need be shortened or not must depend on the degree of displacement of the eye, rather than upon the cause of the displacement.]

former suture is then passed into the wound, insinuated between the sclerotic and the conjunctiva, and made to emerge on the vertical meridian, over the attachment of the superior rectus. The needle carrying the latter suture is brought out in the same way over the inferior rectus; and the tendon is then cut off behind the ligature which is tied round it, and immediately in front of the sutures, but not so close to them that they will be liable to break through. By means of the sutures, the shortened tendon is brought carefully up as near as possible to the margin of the cornea, and they are firmly tied, each including a broad bridge of conjunctiva and subconjunctival tissue, and the two serving to extend the tendon, and to keep it smoothly applied to the sclerotic surface. The tied gut sutures occupy the corneal extremity of the conjunctival wound, the rest of which may be united by one or two sutures of fine silk. Lastly, the external rectus tendon of the other eye should be divided subconjunctivally; or, if the divergence were only slight, this step may be postponed for a few days, and only taken if the result first obtained should prove insufficient. The operation being completed, the squinting eye should be left in a position of considerable convergence; and both eyes should at once be closed by a well-applied compressive bandage, so as to do away with muscular movement as completely as possible. After forty-eight hours, the working eye may be restored to freedom, and the silk sutures may be removed from the conjunctiva of the squinting eye; but the gut sutures may be suffered to remain for a week, unless they loosen themselves or produce irritation. The squinting eye should be bandaged for at least a week, and may be covered with a patch for a fortnight longer, while its fellow should be used very sparingly. By the end of the third week the sutured tendon will be firm in its new position, and the final result will be manifest. It is conceivable, but I have not seen it happen, that the squint may be ultimately reproduced by the continued influence of its original cause. I have seen this after other forms of operation; but not, as yet, after that which is above described.

[Dr. J. F. Noyes, of Detroit, has described a very simple method of advancing the external rectus muscle, which would seem to be equally applicable to the rectus internus. "The patient being fully under chloroform or ether, the lids secured wide open by a stop-speculum, a horizontal incision or slit is made in the conjunctiva directly over the tendon, sufficiently long, through which the tendon is lifted out on a blunt hook. The tendon is then divided near to its insertion on the ball, leaving enough end or stump so that the other end of the divided tendon can be carried under it, lapped, and secured by sutures. The amount of shortening thus effected must, by actual measurement, equal the deviation to be corrected. If it be found necessary to do so, a portion from the end of the tendon may be cut off before carrying it under and lapping, as already described.

". . . . Two stitches only are sufficient to secure the ends of the tendon thus placed until they grow together. Using a curved

needle for this purpose, it is passed first through the conjunctiva, and then from beneath through the tendons; thus placed on one side, it is tied, and then, in the same manner, a suture is placed and tied on the other side. On the third or fourth day after the operation, or longer, the sutures can be removed with safety." (*Trans. Am. Oph. Soc.*, 1874, p. 274.)

In this operation it would be still simpler, and we think better, to insert the sutures before cutting through the tendon. Having raised the tendon upon the hook as described, the needle. armed with fine strong silk, may be passed first through the conjunctiva, from without inwards and two or three lines distant from the corneal margin; next, from within outwards, through one of the margins of the tendon, as far back as may be necessary to effect the required shortening; thirdly, also from within outwards, through the same margin of the tendon, at a point nearer to the scleral insertion, so that the distance between the two points of passage of the needle shall equal the correction which it is proposed to make; and lastly, from within outwards, through the conjunctiva, opposite the point at which the needle was last passed through the tendon. A second needle may be passed in a similar manner twice through the conjunctiva and the opposite margin of the tendon, and the tendon itself may then be divided between the two sutures. On drawing the sutures tight and tying them, the two portions of the divided tendon will overlap to just the required extent, and generally, if the sutures are rightly placed, without having to cut any part of the tendon away. Dr. Noyes described this method as an operation for convergent strabismus, for which, either alone or conjoined with tenotomy of the antagonist, it would seem to be well suited in some of the severer cases in which an operation upon one eye only may be admissible.]

An upward or downward squint is only produced by paralysis of the inferior or superior rectus. When of long standing, it would be incurable; or would be curable only by electrization of the feeble muscle, combined with [or possibly without] tenotomy of the antagonist.

Paralysis of one or more of the ocular muscles generally comes under observation at an early period, when surgical treatment is not required, and when the various forms of the malady are highly interesting and instructive. Every form of such paralysis (I use the word in a general sense, to signify paresis also) is attended by some degree of deviation of one of the optic axes, and by double images if the vision of the two eyes is even approximately equal. The squint may be very large, or so small as to be inconspicuous; and in the latter case it is not always easy to see at a glance which eye is wrongly directed. The smaller the squint, the nearer together will be the double images; and the nearer they are the more nearly equal will they be in vividness and intensity, and the more annoying and disturbing to the patient. If one eye deviates considerably, its image is formed on a peripheral part of the retina,

is comparatively feeble,[1] is a long way from that of the other eye, and may be neglected or forgotten. It is the false image close to the true one, so that the former cannot be ignored, and the two cannot readily be distinguished apart, which produces vertigo and other associated inconveniences.

When a patient complains of double vision, or of double vision and squint, and when there is a manifest squint of one eye in any direction, there can seldom be any doubt which muscle, and, therefore, which nerve, is the one in fault. When no deviation is apparent, the examination is conducted in the following manner:

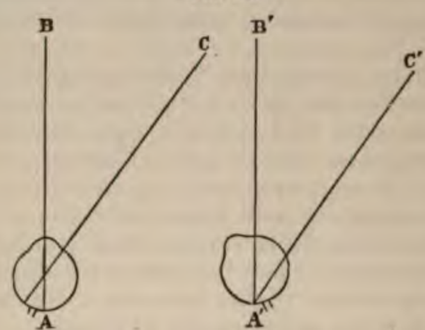
The surgeon, facing the patient, holds up a pencil-case, or other small object, about two feet or so in front of him, and desires him to follow its movements with his eyes, but without moving his head. The surgeon first slowly moves the object to and fro, to test convergence; then, in succession, to the right, to the left, upwards, and downwards. It will generally be found that one eye lags in one of these directions, so that a weak muscle among the recti becomes declared. When this test is not sufficient, the next is to hold the object nearer to the eyes than before, and to shut it out, first from one eye and then from the other, by the interposition of the hand or of a hand-screen. When the deviating eye is thus covered, the correctly fixed eye does not move; but, when the latter is covered, the former instantly moves to fix the object. In this way the deviating eye may be readily determined.

The faulty muscle and the direction of deviation may also be shown by the position of the false image (that of the deviating eye). The patient should be placed eight or ten feet from a lighted candle, in an otherwise darkened room, and he will see two flames. If a slip of red glass is held before one eye, the image belonging to that eye will be colored red, and will be plainly distinguishable from the other. It is usually best to place the red glass before the non-deviating eye; and then to make the patient describe the exact position of the white flame in relation to the red one, how far it is from it, whether above or below, to the right or to the left, and whether in the same horizontal or vertical plane, or in some intermediate one. The false image is always projected in a direction contrary to that of the deviation of the cornea. If the right cornea deviates inwards, the image of the right eye will be outwards, towards the patient's right, and *vice versâ*. If the cornea deviates upwards, the image will be downwards, and so on. In Fig. 106, the diagram A shows a right eye naturally placed to look towards an object (B) situated in front of it, and having on its far right the object C. The ray from B falls on the yellow spot external to the optic nerve; the ray from C falls on a portion of retina internal to the optic nerve, and there makes an impression which is interpreted by the consciousness as an intimation that there is an object in the direction C. In the second diagram, at

[1] [Rather, the perception is feeble. See page 74.]

A′, the same eye is drawn with its cornea deviating inwards, as if from spasm of its internal rectus; and, as the globe rotates about its centre, the posterior hemisphere is necessarily made to deviate outwards. In this position, the ray from the object at B′ falls on the part of the retina which previously received rays from the far right; and the consciousness misinterprets the impression, and refers the source of the ray to the position C′; or, as it is said,

FIG. 106.



projects the image in that direction. If the deviation is due entirely to the fault of one rectus muscle, the false image will be to the right or left of the true one on the same horizontal plane, or accurately above or below it on the same vertical plane;[1] but if the participation of one of the oblique muscles, or the disturbance of harmony between the muscles generally, should produce, as it often produces, some compound form of deviation, or some rotation of the globe about its antero-posterior axis, then the false image will be in some intermediate meridian, to the right or left of the true image as well as above or below it. The relative positions of the two images may be conveniently ascertained by holding up a white rod, or a roll of white paper, in a vertical position, as an object of vision. The two images may then be either placed vertically, one above the other, or laterally to each other; or the false image may be displaced both laterally and vertically, or it may be oblique [in direction] with reference to the true one. It is manifest that a purely vertical displacement points to paralysis of the superior or inferior rectus only;[2] and a purely lateral displacement to paralysis of the internal or external rectus only. A displacement which is both lateral and vertical, but in which the images are parallel, shows that the external or internal rectus participates in the weakness of the superior or inferior, or *vice versâ;* and a displacement in which the images are no longer parallel

[1] [The movements of the eye directly upwards and downwards are resultants of the action of two muscles, the superior rectus and inferior oblique, or the inferior rectus and superior oblique; hence, paralysis of a superior or inferior rectus gives rise to a diplopia, which is not accurately vertical.]

[2] [See last note.]

shows that the eyeball has undergone some rotation on its axis, or that it has failed to undergo the rotation proper to the direction in which it is turned, either by the participation of one or both of the obliqui, or from their action being uncontrolled by that of other muscles. The only muscles which are very liable to isolated paralysis are the external rectus and the superior oblique, each of which has its own special nerve; while the others, being all supplied by branches of the third nerve, are more usually paralyzed together, although sometimes in different degrees. In paralysis of the external rectus, the affected eye cannot be turned far towards the side of the paralyzed muscle, and homonymous double vision of objects situated in that direction is produced. In paralysis of the superior oblique, the apparent movements of the eye are very little affected. The double images are seen only in looking downwards, they are homonymous, the false image is displaced both laterally [outwards] and vertically [downwards], and is oblique, inclining towards the true one at the top. In the many possible varieties of paralysis, the relative positions of the two images vary accordingly; and it would be beyond the scope of this treatise to enter fully into details which are curious and interesting as illustrations of physiological function, but which have little or no bearing upon treatment. For the purposes of the practitioner it is generally sufficient to know that the fourth or the sixth nerve, or the third either partially or collectively, is that upon which the muscular affection is dependent.

It will be remembered that the third nerve supplies the levator palpebræ, the superior, internal, and inferior recti, the inferior oblique, the sphincter pupillæ, and the ciliary muscle. When it is paralyzed as a whole, therefore, the group of symptoms is exceedingly characteristic. The upper eyelid is closed, and presents a curiously flaccid and smooth appearance, its ordinary wrinkles having disappeared. When the fallen lid is lifted, the cornea is found directed towards the temporal side, and immovable by the will in all other directions. The pupil is dilated in a moderate degree, showing paralysis of the sphincter without spasm of the dilatator, and the vision of the eye is impaired so far, and usually so far only, as it is dependent upon accommodation. When both eyes are directed to an object, it is seen singly as long as it is held towards the outer side of the affected eye; but in all other positions there are crossed double images. When the paralysis is partial—that is to say, when it affects certain parts of the nerve only—the group of symptoms above described will be modified by the absence of some of its members; thus there may be no falling of the upper lid, or no dilatation of the pupil or paralysis of accommodation. Paralysis of the fourth nerve, which supplies only the superior oblique, or of the sixth, which supplies only the external rectus, cannot, of course, be partial in the sense above indicated, although it may be complete or incomplete as a matter of degree. The symptoms of these last varieties have already been sufficiently described.

As a matter of fact, paralysis of one or more of the intracranial nerves is, in the greater number of cases, a consequence of syphilis; but it may be produced by syphilis in different ways, as by pressure upon a nerve trunk by thickened periosteum, or by interference with its central ganglia by a gummous tumor. It may also be produced, of course, by a variety of other lesions; and the questions which should be answered, in any case, are, first, whether the paralysis is due to a cause operating upon the centre of the nerve, or upon its trunk; secondly, whether this cause is of syphilitic origin? It is not always possible to answer either of these questions with certainty; but the symptoms will often justify some conclusion. When more than one nerve is affected, as, for example, in the case related at page 117, it becomes nearly certain that the disease is not central, but that the trunks are compressed where they lie in juxtaposition; and, when paralysis of the third nerve is only partial, it may be evident that all the branches given off in front of some given point are implicated, while all those given off behind that point have escaped. Such an anatomical distribution of the paralysis would often show the seat of mischief, although it must be remembered that it might be produced by central disease of such a kind as to implicate the origins of certain filaments only. There is one form of double vision of extremely grave import, in which the extent, and even the kind, of the deviation varies from day to day, the images neither maintaining the same distance apart nor the same relative position, and the squint being larger at some periods than at others. This form is generally, perhaps always, associated with progressive locomotor ataxy, of which it is often a precursory symptom; and it seems to depend upon want of co-ordination and harmony among the ocular muscles, like that which afterwards becomes so manifest in the muscles of progression. The eyes, in such cases, may almost be said to reel and stagger; and the traditional diplopia of intoxication, if those who suffered from it were able to describe it accurately, would probably be found to possess somewhat the same character.

It follows that, in every case of paralysis of any ocular muscle, the examination of the patient should always have reference to the possible existence of disease of the nervous centres; and that all the evidence either for or against this supposition should be weighed with scrupulous care The family and personal history with regard to neurotic maladies, especially with regard to migraine, the presence or absence of headache, sickness, or vertigo, the state of the memory and other mental faculties, the character of the sleep, and the normal or abnormal state of the emotions, should all be inquired into. The vision should be tested after any paralysis of accommodation which may be present has been corrected by a lens; and the circulation upon the optic disk should be studied in the erect image, with a view to the discovery of obstruction or œdema. Even if only a negative conclusion can be reached by these means, such will at least justify a hope that the cause of the paralysis may be extracranial; and then, unless it is produced

by an orbital tumor, which would soon give other evidence of its presence, there is little but periosteal or neurilemmar thickening left to be taken into account. Such thickening may be syphilitic, or rheumatic, or gouty; but the syphilitic cases are more numerous than all others put together. An exception to this statement must be made in the single case of paralysis [paresis] limited to the muscle of accommodation and the sphincter of the pupil; an affection which often follows exhausting illness, and which is well known to be among the common consequences of diphtheria. Such paralysis is usually recovered from as strength is regained; but in a few instances I have seen it permanently established in one of the eyes.

As regards treatment of the early stages of paralysis, there are either two remedies or none; and the remedies, it need hardly be said, are mercury and iodide of potassium, or rather, perhaps, iodide of potassium and mercury. The iodide has the advantage of being useful in nearly all cases, syphilitic or not; while the mercury is only required for the former, and not always in them. Concerning the methods of administration of either, or both, I have nothing to add to the general principles which I have elsewhere endeavored to lay down (Chap. IV); while it need hardly be said that tonics may be given at the same time if they are indicated, and that the general health and habits of life must be taken into account. It will be useless to prescribe iodide of potassium for the removal of gouty or rheumatic deposit, so long as the patient is allowed to lead a sedentary life, or to consume an excessive quantity of food or drink. When the mere symptom of double vision is a source of great distress, it may be obviated during the period of treatment by covering one eye with a patch, or by wearing spectacles one lens of which has been coated by opaque varnish; and some plan of this kind will be required in the majority of instances. In the consulting room, it is often possible to unite the images and to correct the double vision by placing a prism before one eye; but this expedient is not found to be practically available for persons who are engaged in the work of life, and who require to exert constantly varying degrees of ocular convergence, in order to look at objects at varying distances. For paralysis of the accommodation and of the sphincter of the pupil it is usually proper to employ the local application of extract of Calabar bean;[1] and, when the external muscles are affected, and the deviation remains after the primary nerve lesion has passed away, our best hope of success will be afforded by tenotomy and faradization.

[1] [In mydriasis and paralysis of accommodation we have seldom derived any lasting benefit from Calabar bean, and its use has generally been attended with some degree of discomfort. We have, on the whole, succeeded best by prescribing spectacles, ordering a plane glass for the unaffected eye, and for the affected eye a convex glass of such strength as shall nearly, but not quite, supply the place of the deficient accommodation. If the accommodation becomes stronger under the use of the glasses, we may soon change the convex glass for a weaker one, and thus, by carefully regulated exercise, possibly improve or restore the weakened function.]

The ocular muscles occasionally, but only rarely, suffer from spasm, and this, as well as paralysis, may be a source of double vision. Setting aside the spasm of ametropia, which affects the internal recti in hypermetropia and the ciliary muscle in myopia, and which is readily explicable as a result of functional derangement, spasm may occur as one among the symptoms of hysteria, or as a result of disturbance of the circulation of the brain, due either to temporary or to permanent causes. A middle-aged man, otherwise apparently in good health, lately applied at St. George's Hospital on account of double vision which had appeared suddenly. I found spasm of both internal recti, producing convergent squint, and associated with spasm of the ciliary muscles and of the sphincters of the pupils. In the absence of any special indication for treatment, I put him upon iodide of potassium—and, whether as an effect of the medicine I cannot say, in a few days his symptoms disappeared.

[The prevention of strabismus, and its cure in its incipient and early stages, is too important a subject to be wholly passed over in this connection. It is now well understood that convergent strabismus is ordinarily dependent upon a hypermetropic conformation of the eyes, the excessive accommodative effort requisite for clear vision leading in many cases to similarly excessive convergence, which, at first periodic, becomes afterwards constant, and soon increases to become a very conspicuous deformity. Convex glasses, of appropriate strength to correct the hypermetropia, restore the normal balance between accommodation and convergence, and thus may prevent the development of squint by removing its cause.

The treatment of commencing squint by convex glasses, although perfect in theory, is not always of easy application. Squint is generally developed in early childhood, and as it is not always easy to make a young child wear glasses with the requisite persistency, the treatment often fails or is prematurely abandoned. In other cases, however, it succeeds perfectly.

Another plan of treatment, quite distinct from that by convex glasses, is to sever the physiological connection between accommodation and convergence by temporarily suspending the former of the two functions by atropia. Under the full influence of atropia accommodation is impossible, and all accommodative effort ceases as soon as it is found to be ineffective. Under atropia, then, the visual axes may become perfectly parallel, and remain so as long as the effect of the atropia is maintained. The treatment by atropia may be kept up for months, or years if necessary, and thus the habit of binocular vision may be cultivated and preserved indefinitely. Reading is rendered possible and easy by the aid of strong convex spectacles, and a neutralizing convex eyeglass may be used to [illegible] distant vision. Sooner or later, in most cases, the hab[illegible]lar vision becomes so far strengthened by use as [illegible]ble to maintain it by neutralizing

convex glasses alone, which then answer for vision at all distances alike, and the cure is complete.

In practice, a few points should be especially regarded:

First. The atropia must be so used, always in the non-deviating eye and generally in both, as to secure and maintain its full mydriatic effect, and the glasses prescribed for reading or study, must be of such strength as both to neutralize the hypermetropia and supply the place of the suspended accommodation.

Secondly. The treatment by atropia must be kept up in many cases for a long time, often for several months; the progress of the cure being occasionally tested by the temporary suspension of the remedy, the patient meanwhile wearing neutralizing convex glasses.

Thirdly. If astigmatism is present in any high degree, it should be carefully corrected, together with the hypermetropia, in the glasses to be worn after suspending the use of the atropia.

Fourthly. In case of a relapse the use of atropia should be at once resumed.

By following the general course just indicated we find it quite practicable to treat convergent strabismus, in its earlier stages, even in children of three years of age or younger. Under atropia convex glasses are so great an aid to vision that they are readily accepted; with them reading and study become easy, and binocular vision, if once re-established, is permanently preserved, a result which is, we think, worth all that it costs in the way of trouble and the exercise of patience.

If the deviation has become fixed before trial of the atropia treatment, we think it best to correct it early by tenotomy; but we think it very important first to test the condition of the recti muscles by the use of atropia for a longer or shorter time. After tenotomy, also, we often find in the temporary use of atropia an indispensable aid to the successful use of such convex glasses as may be necessary, whether to improve vision or to prevent the tendency to relapse.]

CHAPTER XV.

THE USES AND SELECTION OF SPECTACLES.

It may safely be laid down as a general rule, to which there are only few exceptions, that a case in which there is tolerable vision under some particular conditions, but in which this tolerable vision is subject to unusual limitations, or in which t the eyes

is productive of discomfort that soon passes into pain,[1] or even into more serious symptoms, is one that may be relieved by spectacles. The various sources of physical imperfection which are inherent in the structures of the eye become causes of discomfort, most frequently, by creating a necessity for inordinate muscular exertion. In order to make this clear, it is necessary, even at the cost of repeating what has already been said in earlier portions of the volume, to glance at the muscular efforts which are required for normal vision. These are of two kinds: the accommodation, which optically adjusts each eye singly for the object to be looked at; and the convergence, which directs both eyes in such a manner that the image of the object shall be formed upon the yellow spot of each. The accommodation provides for clear and defined images: the convergence provides for single vision with the two eyes.

The first thing which is essential to the formation of a clear and defined image is that the rays of light proceeding from the object looked at shall be accurately focussed upon the percipient layer of the retina; and the fulfilment of this condition implies also the existence of a definite relation between the refracting power of the eye and the length of its antero-posterior axis. In a normal or ideally correct eye, this relation is such that, in a state of rest, the parallel rays proceeding from infinitely distant objects are those which are correctly focussed; and it follows that divergent rays, proceeding from some nearer point, would have their focus behind the retina. As a matter of fact, however, the eye does not recognize very small departures from parallelism; and we may, for all practical purposes, consider those rays parallel which proceed from objects more than about twenty feet distant. Within this limit the rays begin to be [sensibly] divergent, and become more so the nearer to the eye is the point from which they proceed. While the normal eye remains at rest, therefore, it has clear and distinct vision from the horizon to a distance of [about] twenty feet. Objects which are within this distance will appear more or less dim, and the nearer they are the less clearly will they be defined.

By the action of the ciliary muscle, the eye is enabled to increase its refractive power, and hence to obtain clear vision from divergent rays. As the object of regard approaches nearer and nearer, the ciliary muscle of the normal eye is called into activity, and the divergent rays are still focussed upon the retina, until a point is reached at which the muscle can make no greater effort. This is the "near point" of distinct vision, and within it all objects appear dim. If we take a page of print, and bring it gradually towards the eye, we shall find that at some definite distance the characters are no longer distinguishable.

[1] [There is unfortunately a very considerable class of asthenopic cases whose chief characteristic is discomfort or pain on using the eyes, in the treatment of which spectacles either afford no relief or play a comparatively unimportant part.]

In order to prove that the dimness of near objects is due to the divergence of the rays proceeding from them, we have only to look at the page through a pinhole in a card. The effect of the small aperture will be to cut off the external or more divergent rays of the pencils proceeding from each letter, and to admit only those which are central and approximately parallel. The result will be that the page can be read much nearer to the eye than before; and a man of middle age, whose unaided near point for small type is say at twelve inches, will be able to read the same type at three inches through a pinhole.

The change which takes place in the adjustment of the eye, when it is turned from a distant to a near object, is known as "accommodation;" and the occurrence of an actual change has been proved, not only by reasoning, but also by direct observation. I have already mentioned the simple experiment devised by Donders for this purpose. If we hold a veil at some inches from the eye, and a book beyond it at a greater distance, we can at will see accurately either the texture of the veil or the letters of the book, but never both together. If we see the texture of the veil, we cannot distinguish the letters of the book; if we read, the veil produces only a feeble, almost uniform, obscuration of the field of vision; of the separate threads we see scarcely anything. The craving of the eye for clear images is one of the strongest of our instincts; and, wherever we look, the adjustment necessary to its gratification is effected, not only without any voluntary effort, but often without any consciousness of change. This will be clearly shown if we vary the experiment of Donders, by moving the book out from behind the veil to a lateral position with regard to it, but still preserving the original distance of each from the eye We shall then find that we see either the texture or the letters clearly as the gaze turns from one to the other; and that, unless the nearer of the two is too near for comfortable vision, we shall have no knowledge either of effort or of relaxation when the change of direction is made.

The manner in which the increased refraction of the eye in accommodation is brought about, is by an increase in the convexity of both surfaces, but chiefly of the anterior surface, of the crystalline lens. The power of effecting this change is at its maximum in early life, when the texture of the lens is soft. From about the age of eleven[1] the power gradually diminishes; and, as the lens increases in firmness, the near point recedes further and further from the eye. For many years this change is productive of no inconvenience; but, as life advances, a time comes when the near point is too far away for the requirements of the individual. In reading, for example, the necessary distance of the page becomes so great that the eye no longer receives sufficient light from it; and the elderly reader is forced either to read only in good daylight, or to place his artificial light very near his book. Such a con-

[1] [Probably much earlier.]

dition is called presbyopia, or aged sight; and this word should be strictly limited to impairment of accommodation in healthy eyes, depending upon the changes incidental to advancing life. As these changes are progressive, none but an arbitrary line can be drawn to mark the commencement of presbyopia; and, as they are physiological, they are to be regarded with no anxiety. The inconveniences attendant upon presbyopia are to be relieved, in great measure or entirely, by the use of proper spectacles; and the time when these should be employed must be determined by two considerations,—the distance of the near point, and the occupations of the individual. The mode of action of the spectacles, and the principles which should govern their application, will be further discussed in the sequel.

As regards the accommodation, we have seen that a normal eye is passive or at rest when directed to objects more than twenty feet distant; and that within this range its power of adjustment is brought instinctively and involuntarily into play, at first slightly, but in a constantly increasing degree as the object approaches, until volitional effort is superadded, and at last a near point is reached, within which the ciliary muscle can no longer overcome the divergence of the rays of light, and no clear vision is possible except by the aid of some form of optical instrument. Such an eye is called by Donders "emmetropic."

The maximum of accommodative adjustment of which an eye is capable, like the maximum of any other muscular effort, cannot be long maintained without fatigue; and hence no one can read continuously at the actual near point. The page or the work must be held so far beyond the near point that the effort required for adjustment is not excessive; and it has been ascertained that an exertion of about half the total power of accommodation is as much as can generally be borne for any lengthened period. A person whose near point has receded to a distance of ten inches from the eye would find any continuous work irksome, unless the object looked at could be kept nearly twenty inches away.

It is obvious that an eye may depart from the emmetropic standard in either of two opposite directions. As shown in the diagram on page 39, it may be either longer or shorter than the focal length of its refracting media. All such departures from normal proportion are included by Donders under the name of ametropia—a word to which there is the single objection that it is liable to be confounded with emmetropia, unless we give the continental sound to the *a*. The form of ametropia in which the eyeball is too flat, in which its antero-posterior axis is shorter than its focal length, is called by Donders hypermetropia; and this term has been very generally accepted. The opposite condition, in which the eyeball is elongated, and the antero-postèrior axis is longer than the focal length, might be appropriately called brachymetropia, or, as suggested by Scheffler, hypometropia; but it is so generally known as myopia that this trivial appellation is not easy to discard.

It is plainly apparent that either form of ametropia is calculated to modify the relations of muscular effort to near vision, as far as accommodation is concerned.

In the case of hypermetropia, where the focus of parallel rays would be behind the retina, the clear vision of even distant objects requires an effort of accommodation; and this effort is of course increased when near objects are looked at. It follows that the eyes are never at rest unless closed. The instinctive desire for clear images compels accommodation at all other times; and to turn the eyes to distant objects gives only comparative, not absolute, repose. While the faculty of accommodation is in full vigor, and especially when the degree of hypermetropia is not great, the subject may accomplish the necessary effort without sensible fatigue. But if the hypermetropia is itself considerable, or when the faculty of accommodation becomes diminished either by age or by participation in general bodily weakness, the strain of constant and excessive exertion becomes more than the eyes can bear, and leads to much pain and inconvenience while they are in use, as well as to dimness of vision when the effort is involuntarily relaxed.

In myopia, where the focus of parallel rays would be in front of the retina, and clear vision is obtained only from the divergent rays proceeding from near objects, the function of accommodation may remain almost entirely, or in high degrees of myopia entirely, in abeyance. If, for example, a person is so shortsighted as to have no clear vision of objects which are distant more than six inches from the eye, he will have no need of accommodation unless he wishes to bring them still nearer than this—a condition seldom likely to be fulfilled.

The second faculty conducive to vision for which muscular effort is required, is that of so directing the two eyes that the image of the object looked at falls upon the posterior pole of each, or upon the yellow spot of the retina, by which arrangement single vision with two eyes is obtained. Disregarding the more complicated movements by which the gaze is directed towards objects placed laterally, I will confine myself to the common case of some object situated at the level of the eyes, directly in front of the observer, and capable of being moved to and fro in a direct line. In such a case the direction of the eyes is accomplished almost entirely by a greater or less effort of the internal recti muscles, and is simply a greater or less degree of convergence. For an object at a distance the convergence is trifling in amount; but as the object approaches, the convergence becomes considerable, and may be easily watched by moving any small object to and fro before another person, whose attention is steadily directed to it.

The functions of accommodation and of convergence, both muscular, are both governed by branches of the third nerve, in response to impressions made through the retinæ upon the sensorium. Although essentially independent, they are always performed together in normal eyes, and they become so associated by habit

that any attempt to exert either of them singly is usually painful or futile. A person with normal eyes, not yet become presbyopic, will read for any reasonable time without fatigue, holding a book eighteen inches from the face, and exercising the necessary degree both of accommodation and of convergence. The same person will also look without fatigue over a distant prospect, exercising neither accommodation nor convergence in any appreciable manner. But if we set him to read at eighteen inches with magnifying spectacles of eighteen inches focal length, or to look at the landscape with concave spectacles of the same power, the eyes will speedily ache beyond endurance. In the former case the spectacles render the rays of light parallel, and so the accommodation is at rest while the convergence is exerted to fix the eyes on a near object. In the latter case the spectacles render the rays as divergent as if they proceeded from an object eighteen inches distant, and accommodation to that extent becomes required; while the real distance of the scene precludes any corresponding effort of convergence. Convergence in the absence of accommodation, and accommodation in the absence of convergence, are equally painful and distressing

The action of a prism in displacing the apparent position of objects may be used to prove the character of the uneasiness produced by either of the experiments with spectacles above described. A pair of prisms, each of seven and a half degrees of angular measurement, placed with bases inwards before the convex lenses, or with bases outwards before the concave lenses, will instantly remove all inconvenience. In the former case they relax the convergence to parallelism, to correspond with the relaxed accommodation; in the latter they produce convergence to a point eighteen inches distant, to correspond with the effort of accommodation. In the former case they relax muscular action; in the latter they call it into play; but in both the discomfort and fatigue resulting from the derangement of the natural harmony between accommodation and convergence are immediately relieved. It is necessary, of course, that the prisms should not be rotated about the visual line, but that the thickest and thinnest part of each should be accurately in the same horizontal plane, so as to avoid displacement of either image upwards or downwards.

In ametropic eyes, of whatever character, the normal relation between accommodation and convergence is broken through. The hypermetrope is always called upon for a degree of accommodation in excess of his convergence; the myope, for a degree of convergence in excess of his accommodation. Early habit and constant practice will do much to diminish the irksomeness of this disturbance of natural co-ordination; but still it seriously impairs the working power of the eyes, and perhaps explains, even more than the actual amount of effort demanded from them, why their muscles so often break down and fail. The muscles of accommodation of the hypermetrope, the muscles of convergence of the myope, are those in which the failure usually becomes apparent;

although in some cases, in which the natural harmony of the two functions is stronger than the demand for [single or] clear images, another result is produced. In hypermetropia, a degree of convergence which keeps pace with the accommodation is the ordinary cause of strabismus; and myopia is often aggravated by spasm of the accommodation, which is not an aid to vision, but which simply keeps pace with the required effort of convergence.

In order correctly to estimate the values of the various elements concerned in the muscular efforts of the eye, it is necessary to reduce them to numerical standards. For this purpose the degree of ametropia is expressed by the reciprocal of the focal length, in Paris inches, of the lens which corrects it; and the power of convergence by the degrees in angular measurement of the prism which it can overcome. For example, a myopia may be such that a six-inch or an eight-inch lens corrects it perfectly, and enables the myope to see the horizon. We then describe the myopia as being equal to $\frac{1}{6}$ or $\frac{1}{8}$,[1] using the reciprocal instead of the whole number, because the myopia which requires a six-inch lens is greater than that which requires an eight-inch, and the fraction $\frac{1}{6}$ is greater than $\frac{1}{8}$. A myopia equal to $\frac{1}{6}$ will plainly be one in which the person has no distinct vision, when unaided, of any object that is more than six inches distant from the eye; but the concave lens gives to parallel rays a divergence as if they proceeded from a point six inches away, and thus enables them to be united upon the retina. Hypermetropia is expressed in the same way, but its degree is less easily determined, on account of the action of the ciliary muscle in diminishing the apparent defect. For example, a person may have hypermetropia which requires an eight-inch convex lens for its absolute correction, so that rays passing through this lens will be united upon the retina when the eye is at rest. But the ciliary muscle, by rendering the crystalline lens more convex, may habitually overcome and conceal half of this hypermetropia, in which case it is said to render it latent, leaving the other half manifest. The person would then say that a convex lens of 16 inches focal length improved distant vision, while a stronger one rendered it obscure; and it would still be uncertain how much the ciliary muscle was acting, and how much hypermetropia was rendered latent by its means. This difficulty is overcome by the use of atropine, which for a time paralyzes the accommodation, and brings the latent hypermetropia into view. For this purpose the solution of atropine or of its sulphate should be of the strength of at least four grains to the ounce, and a large drop should be placed in the eye two or three times, at intervals of an hour, the last application being made about two hours before the time of examination. Young subjects will sometimes entirely conceal even very high degrees of hypermetropia, and will reject the weakest convex

[1] [This is not strictly correct, for the reason that the position of the correcting glass is half an inch or so in front of the eye. The actual myopia is somewhat less, and, on the other hand, the actual hypermetropia is somewhat greater than the value of the correcting glass.]

glass until atropine has been used. Without atropine, however, we shall often find that some weak convex glass, as a 30 or 36-inch, improves distant vision, and we then say that there is manifest hypermetropia equal to $\frac{1}{30}$ or $\frac{1}{36}$. After the atropine, we may find that a convex of fifteen or eighteen inches is required, and we say that the total hypermetropia is equal to $\frac{1}{15}$ or $\frac{1}{18}$. The difference between the manifest and the total is, of course, the amount which is latent, and this affords the measure of the accommodation effort which is habitually made when the eyes are directed to distant objects, and which is much increased when they are directed to near ones.

For estimating the convergence we require pairs of prisms, one of which is placed, with its base outwards, before each eye, until the internal recti muscles can no longer fuse the two images into one, and double vision is the result. The most powerful prisms which can be overcome, so as to maintain single vision of an object in spite of them, furnish the measure of the strength of the convergence faculty. Perhaps the best test object is a lighted candle, in an otherwise darkened room, at a distance of six or eight feet from the spectator. The prisms are named by their angular measurement in degrees, so that the higher numbers are the stronger, and whole numbers are used instead of fractions. If the eyes can overcome a pair of seven degrees, and are beaten by a pair of eight degrees, we say that the total convergence is equal to fourteen—the sum of the highest pair which can be conquered by the muscles.

In estimating either myopia or hypermetropia, it will sometimes happen that the patient finds it difficult to decide between two or three lenses of nearly equal power, and gives the preference now to the stronger, now to the weaker of them. When this is so, we must suspect the presence of the complicated form of ametropia which is called astigmatism [or sometimes of accommodative spasm].

The surface of the cornea is not always, or even usually, a portion of a perfect sphere. If we draw two imaginary lines bisecting it, one vertical and the other horizontal, and call them the vertical and horizontal meridians, we may easily find that there is, in most eyes, a slight difference in the curvature in these two directions. If the eye is emmetropic in one of the meridians, it will probably be slightly ametropic in the other; and, if ametropic in both, there will still be a difference between the two. It has been surmised that by this arrangement the eye is preserved from ever being accommodated so precisely for the plane of a surface as to lose all definition on either side of this plane; that it gains, indeed, something of the quality which is called penetration in microscopic object glasses.[1] Be this as it may, the difference is almost universal, and makes itself felt by the circumstance that few people have precisely the same vision for horizontal as for vertical lines. In many instances, however, the meridians of

[1] [Astigmatism is always a positive defect.]

greatest and least curvature are not exactly vertical and horizontal, but occupy some intermediate positions, though always at right angles to each other. The effect of the difference between them is that the eye, as a whole, has no single focus; and hence it is said to be astigmatic.

When astigmatism is present in any marked degree, its effect upon vision is to require two separate accommodation efforts for the different aspects of every object which is looked at. If we take small type as the object, and the form of astigmatism in which there is more hypermetropia in the vertical than in the horizontal meridian as an example, the horizontal boundaries of every letter will require a greater accommodation effort than the vertical boundaries, as if the former were nearer than the latter. Each letter, under such circumstances, has first to be defined from those before and after, next from those above and below it. The muscle of accommodation, by this necessity, is called upon for an indefinitely greater effort than would be involved in the maintenance of even a higher degree of constant exertion; and fatigue is soon experienced.[1]

In the case of all the muscular efforts which are necessary to clear vision, fatigue, by producing relaxation of muscle, produces also dimness of sight. The myope, who can no longer maintain the degree of convergence which his imperfection demands, suffers from double vision, which, although seldom sufficient to give two separate and detached images of each word or letter, is yet sufficient to obscure its outlines. The hypermetrope, or the astigmatic, who can no longer maintain the necessary accommodation effort, loses the outlines in a similar way, although from a different cause. In either case the eyes are first said to "ache" [or to feel tired], and then, if work is continued, vision becomes misty and dim. Excessive nervous and muscular effort produce active hyperæmia, followed by passive congestion; and mental anxiety often aids these physical changes in simulating or in producing disease. Of the former effect, when I come to speak specifically of myopia, I shall have to cite a very remarkable illustration.

As might reasonably be anticipated, the power of the eyes to maintain muscular effort, or to endure the strain consequent upon a severance of the natural harmony between accommodation and convergence, is greatly dependent upon the general vigor of the system. The half-starved needlewoman breaks down utterly before a requirement which would scarcely be felt by a healthy and well-nourished person. And on this general principle it frequently happens that a physical defect in the eyes may exist for many years unperceived, and may be suddenly brought into prominence by some change in external circumstances or in general vital activity. In the manner already stated, the power of accommodation, and hence the power to overcome hypermetropia or astigma-

[1] [In reading, a person with astigmatic eyes generally accommodates by preference for the vertical limbs of the printed letters.]

tism,[1] diminishes gradually with advancing life; but this gradual diminution may steal on almost unperceived, and may first make itself felt after some illness or accident, or after some period of unusual mental or bodily exertion, to the direct influence of which it may then be erroneously attributed. I have many times seen cases in which an obvious physical defect had been overlooked, or rather had not been looked for, because it was supposed that a recent impairment of vision could only be due to causes newly in operation.

Proceeding from these general principles to the management of particular defects, we find that the simplest form of discord between the muscular actions of the eyes is that which occurs in ordinary presbyopia. In this condition, while the gradual hardening of the lens requires constantly increasing accommodation effort to produce a given effect, no similar obstacle is opposed to the production of convergence. The result is, that the two functions can no longer work harmoniously, and that sensations of fatigue and straining are produced. Let us assume that eighteen inches is the normal reading distance for an adult, and that precisely parallel efforts are required to accommodate each eye for, and to converge both eyes to, that distance. After a while presbyopia steals on; and then the patient requires as much accommodation effort to give clear vision at eighteen inches as would formerly have sufficed to give clear vision, say, at twelve inches. If he maintains his eighteen-inch reading distance he increases his accommodation effort by one-half, while his convergence effort remains unchanged. If he retains his original accommodation effort, accepting its smaller result, and moving his book to a distance of twenty-seven inches, he then requires to diminish his convergence effort by one-third. In either case, he disturbs the natural harmony between the two functions; and soon suffers from pain or inconvenience. The pain, it must be observed, is produced solely by excess or perversion of muscular effort, and not at all by imperfect seeing. Failing sight *per se*, as, for example, in the case of progressive atrophy of the optic nerve, is painless; and pain is only felt in those cases in which vision is improved so long as a certain muscular effort can be maintained. The fact that the eyes ache after exertion may, as a rule, be taken to prove that the patient suffers from an imperfection which can be relieved or cured by the aid of optical means alone.

It has long been the custom, in the treatment of presbyopia, to commence with very weak convex spectacles, and to advise their use only by artificial light. After a few months or a year these spectacles no longer meet the difficulty. They are then used by daylight, and a stronger pair obtained for the evening. It is found that the presbyopic eyes become tired and strained without glasses, and that they also become tired and strained if the glasses worn

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1 [Accommodative efforts may mask astigmatism, but cannot overcome it. See note to page 44.]

are either too weak or too strong. The *rationale* of this deserves a moment's consideration.

When presbyopia first becomes an inconvenience, it does so simply on account of the breach of harmony between accommodation and convergence. The newspaper, held at eighteen inches' distance, requires as much accommodation effort as would have sufficed, a short time before, for a distance of [say] thirteen inches, but it still requires, of course, only the old convergence effort for the actual distance of eighteen inches. The eyes, therefore, may be regarded as accommodating for thirteen inches whilst they are only converging to eighteen. A convex lens outside the eye rests the accommodation by rendering an equivalent quantity of increased convexity of the internal lens unnecessary. A lens of forty-five inches focal length almost precisely represents the difference between accommodation for thirteen inches and for eighteen; and such a lens, therefore, restores the equilibrium which has been disturbed, and renders the accommodation effort and convergence effort the same. Anything less than this would fail to remedy the inconvenience; and anything stronger—a 24-inch lens, for example—would be an over compensation, which would require an accommodation effort less than that of the convergence, and would produce strain by this new disparity. If presbyopia were a fixed instead of a progressive affection, the 45-inch lenses would cure it once for all. In actual fact they only correct the accomplished portion of a progressive change, and they leave the eyes still on the threshold of presbyopia, compelled to use a considerable accommodation effort. After a time this again creeps so far ahead of the convergence effort that the disparity once more becomes painful, and then stronger spectacles are required in order to redress the balance. An eminent man of science, now deceased, wrote many years ago an article in the *Quarterly Review*, in which he laid great stress upon the evils incidental to increasing the power of the glasses used in presbyopia. His counsels, although they had no root in facts, sank very deeply into the public mind; and it has become a prevailing superstition that glasses of too great strength are above all things to be avoided. It is true that a pair of glasses will produce uneasy sensations as soon as they are strong enough to relax accommodation in excess of the relaxation of convergence; but proof that they do no other harm is furnished by the daily experience of watchmakers and other workmen, who, all their lives long, constantly use a glass of high power for one eye only, and never suffer from doing so. The other eye being closed or disused, no effort of convergence upon the near object is called for; and hence the ease of relaxed accommodation brings in its train no compensating disadvantages.

A moderately strong convex lens is, of course, in many respects much more advantageous than a weaker one. The strong lens allows the object to be brought so near to the eye that the latter receives abundant light; and the greater enlargement of the retinal images affords increased facilities for recognizing their nature. A

person whose presbyopia was but just beginning to make itself felt, and who would not bear spectacles of a higher power than about 30 inches focal length without inconvenience, would find an 18-inch reading lens, for one eye only, perfectly delightful. It would, if we take reading as an illustration, convert a badly printed octavo page into the semblance of a well-printed quarto, enlarging the characters, brightening the general surface, and rendering it easy to read in a comparatively dim or failing light.

The desideratum of the presbyopic, therefore, is a means which shall relieve the convergence strain incidental to a pair of strong lenses, and shall thus render practicable the employment of spectacles which will give rest to the accommodation. The principle on which this might be effected was first pointed out by Dr. Giraud-Teulon; but it was reserved for Dr. Scheffler, of Brunswick, in a treatise which I translated a few years ago, to work out the problem to its solution, and to call attention to some of the various details which it is necessary to consider. Unfortunately, Dr. Scheffler is not himself a practitioner, and has had no opportunity of checking his conclusions by actual experience. It will be necessary first to explain what these conclusions are; and then to mention certain obstacles which stand in the way of their general application.

I have already incidentally referred to the effect of prisms in modifying the action of spherical glasses; and of this effect we have a familiar illustration in the common stereoscope, in which the magnifying-glasses are also prismatic, and enable the spectator to look easily with both eyes at a surface only four or five inches distant.[1] The deflection of light by a prism is of such a nature that any object seen through one has its apparent position moved towards the side to which the edge of the prism is turned. Let us suppose that the object is placed exactly in the middle line in front of the observer, and so that a straight line drawn from it would strike the root of his nose. If the left eye is then closed, and a prism held before the right, the apparent position of the object will be altered. If the edge of the prism is turned outwards towards the temple, the object will appear placed more towards the right of the spectator than its actual position. If the edge is turned towards the nose, the object will be displaced towards the left. The degree of displacement will depend, of course, on the

[1] [The effect of the decentrated or prismatic lenses of the common refracting stereoscope is to enable the two eyes respectively to see distinctly, without accommodative effort, and with parallel visual axes, and so to fuse into the illusory perception of an actual distant object, two pictures, representing the slightly different aspects of the object as it would appear to each of the two eyes singly, and placed near the foci of the lenses, and at a distance from each other greater than the distance between the centres of the two eyes. The proof of this statement is furnished by measuring any ordinary stereoscopic slide, upon which the distance between corresponding points of the two pictures will be found to be about three inches, while the average distance of the centres of the two pupils is only about two and four-tenths inches. If we remount the two pictures nearer together (say 2.4 inches apart) a pair of $+\frac{1}{5}$ or $\frac{1}{6}$ spectacles centrally placed before the eyes will be found perfectly to fulfil, for the reduced slide, the function of a stereoscope.]

distance of the object and on the angular measurement of the prism; but assuming that the object is eighteen inches from the root of the nose, and that the centres of the eyeballs are sixty-six millimetres (rather less than two inches and five-eighths) apart, a prism of seven and a half degrees of angular measurement, with its edge outwards, will bring the object to be apparently opposite the right eye when in a state of repose; that is, will cause an apparent deviation of thirty-three millimetres. In other words, in order, through such a prism, to see the object placed as described, the eye must be directed straight forwards, with its convergence absolutely at rest. If a similar prism is placed before the other eye, this also will be influenced in the same manner; and single vision of the near object will only be gained when the axes of the two eyes are parallel, and all the muscles of direction are passive. At the same time, as the object is really only eighteen inches distant, the rays proceeding from it require an effort of accommodation which, in repose of the convergence, would very soon become painful or fatiguing.

Let us now add to the supposed prisms a pair of convex lenses of 18 inches' focal length. The effect will be that the lenses will remove all need for the exercise of accommodation, while the prisms remove all need for the exercise of convergence; and, as far as regards an object eighteen inches distant, the two eyes may look at it for an indefinite time without muscular exertion. The lenses may be ground upon the prisms by giving the necessary convexity to their surfaces; and we then have what Dr. Scheffler has called "orthoscopic" spectacles.

The precise nature of these combinations will perhaps be rendered more apparent by reference to Dr. Scheffler's diagrams of orthoscopic convex and concave spectacles respectively. In Figs. 107 and 108 the simple actual object *a* is displaced, by means of the lenses, to the distances *g d*, *g' d'*; and, by means of the prisms, in the directions *g e g' e*. There is presented to the eyes, therefore, looking through the orthoscopic spectacles, instead of the single actual object *a*, a single apparent object *e*, and the eyes, looking at *a* through the spectacles, are in precisely the same condition as if they were looking at *e* without spectacles.

It is manifest from the foregoing that every power of lens has a corresponding angular measurement of prism which stands in the "orthoscopic" relation to it; and hence that orthoscopic spectacles may be made of any focal length. But in practice, since the angular measurement of the prism increases rapidly as the focal length of the lens diminishes, and since the increase of the prism implies a great addition to the weight and the thickness of the glass, the range of available powers is very limited. I myself prescribe only four varieties, and, for the great majority of cases, only two. I take as the unit of power a lens of the focal length of 240 centimetres, and the successive steps are equal to two, three, four, five, and six such lenses; while every unit requires a prism of nearly one degree and a half angular measurement. The effect of

the first and second of this series upon accommodation is almost too slight to require the aid of a prism for the relief of the convergence; the third hardly magnifies enough to give the full advantage of an orthoscopic combination; and in the sixth the thickness of the glass is already becoming an inconvenience. But

FIG. 107.

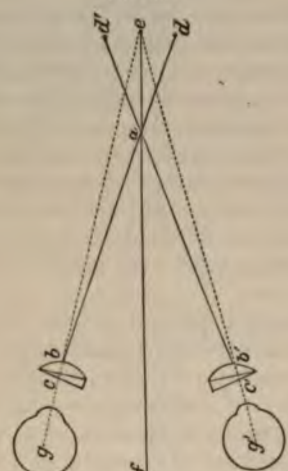
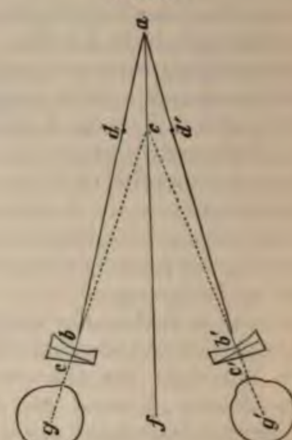


FIG. 108.



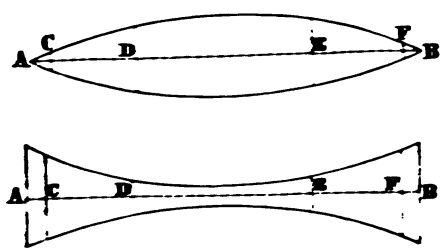
the fourth, a convex lens of sixty centimetres focal length on a prism of six degrees, and a fifth, a lens of forty-eight centimetres on a prism of seven and a half degrees, are combinations of much practical value. On account of the differences between English, French, and German inches, I prefer to state the focal length in centimetres, but the following table gives the exact value of all the factors in the combinations mentioned above:

Number of combination.	Focal length of lens in centimetres.	Focal length of lens in Paris inches.	Angular measurement of prism to form the orthoscopic combination when the centres of the eyes are 66 millimetres apart.
1	240	88.66	1° 29′ 10″
2	120	44.33	2° 58′ 23″
3	80	29.55	4° 27′ 37″
4	60	22.16	5° 56′ 54″
5	48	17.73	7° 26′ 14″
6	40	14.78	8° 55′ 39″

Neither the accommodation nor the convergence is affected by the small quantities expressed by decimals or odd minutes and seconds in the table; and my combinations 4 and 5 are prescribed simply as convex spectacles of 22 Paris inches, or of 18 Paris inches, on prisms of six or of seven and a half degrees. The test of such glasses being perfectly "orthoscopic" is that the two

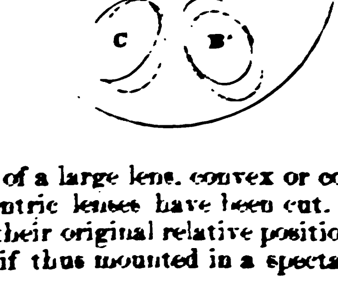
lenses, when fixed in their frame, should cast only a single image upon a screen placed at their focal length; and hence they require careful adjustment on the part of the optician. The reason why they should cast only one image is that each prismatic lens is, in point of fact, an eccentric portion of a larger lens, as shown in the two sectional diagrams in Fig. 109, in which the portions C D, E F, of each of the single lenses A B, represent pairs of prismatic lenses. They are the portions through which the two eyes would respectively look, if a lens of about four inches in diameter were held up before the face with its centre opposite to the root of the nose. The single lens itself would produce only a single image at its focal point; and hence it is manifest that its two eccentric portions will produce only a single image at the same point, or rather will produce two images which will coincide absolutely, so long as the

FIG. 109.



two separate lenses bear to each other precisely the same relative position which they bore as component parts of the larger lens from which they were taken. It is only in this relative position that the two lenses are "orthoscopic." The diagram in Fig. 110

FIG. 110.



gives a front view of a large lens, convex or concave, from which three pairs of eccentric lenses have been cut. These three pairs, while they retain their original relative positions, as shown by the dark lines, would, if thus mounted in a spectacle-frame, be ortho-

scopic. The pair A A′, which are shown by the dotted lines as unduly approximated, if thus mounted, would produce crossed double images at their focal length. The pair B B′, which are shown by the dotted lines as unduly separated, would produce homonymous double images; and the pair C C′, each one of which is shown by the dotted lines as having undergone rotation about an antero-posterior axis, would displace their respective images upwards and downwards. The fault of the pair A A′ might be overcome, at the cost of some fatigue, by the external, and that of the pair B B′ by the internal recti, and each pair might be suitable for some abnormal state of muscles; but the double images caused by the displacement of C C′ could not be combined by any ordinary movement of the eyes, and the glasses would be useless under all circumstances. It is manifest that a small amount of carelessness in trimming and setting prismatic lenses might bring about this very condition; and prismatic spectacles should never be used unless their two images, even if not required to be coincident, are at least on the same horizontal line.

The majority of presbyopic persons are not called upon for any great or prolonged employment of their eyes upon near or small objects, and, becoming gradually habituated to the altered relation between accommodation and convergence which [relatively strong] common spectacles produce, they are able to use them either with entire comfort, or, at all events, sufficiently for their requirements; and they may always be permitted to have power enough to enable them to see without sensible exertion. I never recommend the use of weak common spectacles, which leave the patient struggling, as it were, on the very brink of his infirmity, and compel him always to exert his ocular muscles to the full measure of their powers. It is better to begin with $+\frac{1}{36}$, or even $+\frac{1}{30}$, than with the $+\frac{1}{48}$, or $+\frac{1}{45}$, or even $+\frac{1}{60}$, so often recommended by spectacle-sellers to their customers under the delusive name of "clearers;" and it will generally be found that the early use of adequate power is a source of much comfort and pleasure. But when the presbyopic person is compelled to use the eyes for many hours together in occupations which require near and accurate vision; and especially when, as often happens, one result of such occupations has been to disturb the original harmony of the ocular muscles, and to destroy the natural balance of their powers; then the common glasses often fail either to afford ease or to permit prolonged seeing, and it becomes necessary to introduce the prismatic element, and to study the requirements of the convergence as well as those of the accommodation. In many such cases a pair of orthoscopic spectacles will enable the patient to read for hours without an unpleasant sensation, on the sole condition that his book is kept at, or just a little within, the focal length of the prismatic lenses. There is a perfect absence of effort, as if he were looking at the far horizon; and the sensations of strain which sometimes attend upon common spectacles are entirely removed. The only inconvenience is that the surface of the page is made to

appear somewhat convex; but this soon ceases to be observed. In other cases the orthoscopic glasses not only fail to afford relief, but they even increase the discomfort which was before experienced. When this occurs, some other combination of lenses and prisms is indicated; and Dr. Scheffler has constructed an elaborate series of formulæ for calculating such combinations upon the basis of separate trials of the refraction and of the convergence power. The fact is, however, that the convergence power is very difficult to determine, partly because it may vary from day to day and from week to week in accordance with variations in the general muscular tone, and partly because the surgeon is dependent upon the accuracy of the statements made by the patient, who, in the greater number of instances, has never learned to be accurate. I have had an instrument constructed which promises to reduce the measurement of convergence power to a matter of great simplicity, and to afford a means of checking, in some measure, the correctness of the patient's statements; but I refrain from publishing a detailed account of it until I have had more extended opportunities of testing its utility. In the meanwhile, I am content to arrive at the necessary prismatic spectacles by experiment. I select a pair of lenses with which the patient can barely, in a good light, decipher "brilliant" type at eight inches distance, and I lend him these together with a pair of prisms which will make with them an orthoscopic combination, and a testing frame to hold both the lenses and the prisms in spring clips. I tell him to try this combination for an hour in the evening; and if it does not succeed I vary the prisms, and make a succession of trials until I arrive at some definite knowledge about the case. To do this is often a matter of considerable time and trouble; but the time and trouble are well bestowed. It is often possible to obtain a combination by the help of which occupations that would otherwise strain and tax the eyes may be pursued without sensible effort; and then the muscle of accommodation, being never overworked, preserves its vigor and activity much longer than it would preserve them if it were daily called upon for severe or excessive exertion. I am fully convinced that over fatigue of aged eyes may be an important factor in the causation both of cataract and of glaucoma, and entertain no doubt that a more general employment of prismatic spectacles, in the cases specially calling for them, would very materially contribute to the preservation of sight.[1]

For similar reasons, I strongly advocate the early recognition and relief of presbyopia. The effect of the gradual impairment

[1] [The theory of the action of spectacles which has led a few writers to advocate the general use of prismatic glasses, as well in presbyopia as in the different forms of ametropia, was first worked out by M. Giraud-Teulon. (*Vision Binoculaire*, chap. x, 1861.) The theory of "orthoscopic" glasses is given fully in the work cited, but their grave disadvantage in distorting plane surfaces is recognized as a sufficient reason for rejecting them. Giraud-Teulon advocated the attainment of a very moderate prismatic effect by the decentration of ordinary glasses in mounting them in their frames, a resource which is much oftener of value than the full "orthoscopic" adjustment advocated by Scheffler.]

of accommodation becomes harassing to persons who are engaged in sedentary occupations, generally between the fortieth and the forty-fifth year; but very frequently the use of glasses is still improperly deferred. Some people avoid them in the vain hope of retaining a baseless reputation for juvenility, some on the well-founded but irrelevant plea that if they "take to glasses" they will never be able to lay them aside, some from sheer ignorance or thoughtlessness, many, in the humbler classes of life, as a result of the cruel and preposterous folly of employers, who are supposed to associate the use of spectacles with bad sight, and who, in many cases, will dismiss a workman, or will diminish his pay, as soon as they find that he avails himself of such assistance. It may be assumed that everybody's age is known as accurately as anybody cares to know it; and, since those who desire concealment of truth can hardly be amenable to reason, it would be useless to pursue this aspect of the question further. It is more important for it to be understood that spectacles, instead of being a nuisance or an incumbrance, or an evidence of bad sight, are to the presbyopic a luxury beyond description, clearing outlines which were beginning to be shadowy, brightening colors which were beginning to fade, intensifying the light reflected from objects by permitting them to be brought closer to the eyes, and instantly restoring vision to a standard from which, for ten or a dozen years previously, it had been slowly and imperceptibly, but steadily, declining. This return to juvenility of sight is one of the most agreeable experiences of middle age; and employers may rest assured that an artisan who requires spectacles on account of presbyopia, will work far better with them than for some time previously he had been able to work without them. They may also be assured that, by offering impediments to the free use of glasses in their shops, they not only injure themselves, but they also inflict much unnecessary suffering upon their people. A man with defective sight may not only conceal his infirmity for a considerable time, so as to bungle over a large amount of work before he is found out; but his eyes may also, by reason of the strain which he is not permitted to relieve, become the subject of morbid changes for which perfect relief will no longer be attainable.

The general principle, therefore, on which I treat presbyopia, is to recognize it early, and to give optical help liberally, so as to render the muscle of accommodation not only able to perform its tasks, but able to perform them easily. When more power is required, the stronger glasses should at first be taken into use only by artificial light; and the original pair should still be worn in the daytime. If the glasses fail to relieve discomfort, or if they become sources of discomfort themselves, the strength of the convergence muscles should be taken into account, and an endeavor should be made to give relief by means of prismatic lenses. It is seldom worth while to begin the treatment of presbyopia with lenses weaker than $\frac{1}{36}$; and lenses stronger than $\frac{1}{12}$ will hardly ever be required, even in extreme old age. Between these limits

I generally make four gradations, namely, $\frac{1}{30}$, $\frac{1}{24}$, $\frac{1}{18}$, and $\frac{1}{15}$. A person who is only presbyopic does not want glasses for distance, and hence he may wear his spectacles a little way down his nose, so as to look over them when the eyes are lifted. Some people prefer to have the upper third of the lenses cut away, so as to look over them still more easily; but an ordinary frame worn low will suffice for all usual requirements.

It must never be forgotten that a rapid increase of presbyopia is among the premonitory signs of glaucoma: and hence all presbyopic eyes should be carefully examined, with reference to their acuteness of vision, their tension, and the extent of their field of view, before spectacles are prescribed for them.

In the state of hypermetropia, in which the eyeball is flattened or compressed from front to back, so that its antero-posterior axis is shorter than the focal length of its refracting media, it is a condition of clear vision that this focal length should be diminished by accommodation. The eyes of the hypermetropic person are never at absolute rest during his waking hours. They are compelled to exert the ciliary muscle in some degree even for the most distant objects, and they are compelled to exert it still more for near ones.

The degrees of hypermetropia which are ordinarily met with range from something scarcely appreciable to as much as $\frac{1}{12}$; and cases of $\frac{1}{6}$, $\frac{1}{4}$, and even $\frac{1}{3}$,[1] are occasionally seen. Although an emmetropic eye is the ideally normal condition, I doubt whether it often exists; and my impression is that a very small degree of hypermetropia, equal to about $\frac{1}{80}$ or $\frac{1}{60}$, is the rule in cases of good vision. Between $\frac{1}{60}$ and $\frac{1}{30}$, in persons of ordinary health and strength, hypermetropia chiefly declares itself merely as early presbyopia; and occasions no inconvenience until the thirtieth or thirty-fifth year is past, or until some illness weakens the ciliary muscle in common with others. Between $\frac{1}{30}$ and $\frac{1}{15}$, in the way explained in the preceding chapter, it is the ordinary cause of convergent squint; and above $\frac{1}{15}$, although it seldom causes squint,[2] it renders the unaided eyes practically useless, producing a condition which, before its nature was understood, was described as "asthenopia," or weak sight, and [because not understood] was incurable. These statements as to the effects of the different degrees are approximate and general only; and the effects actually produced will vary with the muscular power and the nervous susceptibility of the individual. In some instances a very low degree of hypermetropia produces much distress; in others, a comparatively high degree is borne with but little inconvenience.

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[1] [Donders cites cases of hypermetropia measuring $\frac{1}{1.5}$ and $\frac{1}{2.67}$; also a remarkable case, communicated by Mr Bowman, of $\frac{1}{1.7}$. Cases of hypermetropia greater than $\frac{1}{3}$ are not very uncommon.]

[2] [In convergent strabismus Donders found the *manifest* hypermetropia to vary from 0 to $\frac{1}{10}$, rarely reaching $\frac{1}{4}$ or more. The *total* hypermetropia of course attained a considerably higher degree than the *manifest*, for even in cases in which there was no *manifest* hypermetropia, and the *total* defect was afterwards measured under atropia, the latter was found to be seldom less than $\frac{1}{15}$.]

The symptoms of asthenopia, in a young subject, are very characteristic. There is, in the first place, good vision of distant objects; seldom $V = 1$ when scientifically tested, but enough to convince stupid parents and blundering school teachers that "the child can see very well if he pleases." This distant vision, such as it is, is the result of strenuous accommodation; and when any attempt is made to read, or to look steadily at near and small objects, the additional effort, even if it can be made at all, cannot be sustained. Sometimes small type cannot be deciphered, sometimes a few words or lines can be deciphered, and then all becomes indistinct. There is a marked tendency to compress the eyeballs by strong action of the orbicular muscles, or by the application of a hand outside the lids, and the resulting gestures are not to be mistaken. After such momentary pressure, the hypermetrope can make a fresh commencement; but, before long, everything near to him again grows dim, and each period of renewed activity will be shorter than that which preceded it. Perseverance in effort will render the eyes painful and congested, and will often produce considerable lacrymation; so that long perseverance becomes impossible. Until quite recent times the ordinary fate of a hypermetropic child was to be the continual victim of unmerited punishments in the school-room, and to be compelled, in after-life, to follow some occupation requiring distant vision only. The late Dr. Mackenzie, of Glasgow, for example, was fond of advising asthenopic men to become sheep-farmers in Australia; and it was not until Stellwag von Carion discovered the cause of the affection, and until Donders fully worked out the problems connected with it,[1] that any advice materially better could be given. Except in those cases in which the defect is complicated with imperfect retinal development, we now, by the use of spectacles, place the hypermetrope upon a footing of equality with the rest of mankind, and enable him, in the phrase once addressed to me by a grateful patient, "to pursue ordinary avocations, and to forget that he has eyes."

It has already been explained that the hypermetropia which exists in any case is apt to be partly concealed by the permanent action or habitual state of the ciliary muscle; and that the portion thus concealed is called latent, to distinguish it from that which is manifest. The manifest hypermetropia is measured and expressed by the power of the strongest convex lens which improves distant vision[2] when the eye is in its ordinary state, and the total hypermetropia is measured and expressed by the power of the strongest convex lens which improves distant vision when the eye has been thoroughly subjected to the influence of atropine. To illustrate this by an example, it might be found that distant vision was assisted by a weak convex lens, say of $\frac{1}{40}$, and a succession of trials might prove that higher powers were more and

[1] [The credit of accurately describing hypermetropia, and the discovery that it is the condition which ordinarily gives rise to asthenopia, is due to Donders.]

[2] [Rather the strongest convex lens through which distant vision continues distinct.]

more useful up to $\frac{1}{24}$, but that $\frac{1}{20}$ produced dimness. In such a case there would be $\frac{1}{24}$th of manifest hypermetropia. After an effectual application of atropine the patient would require still stronger glasses, and would perhaps stop at $\frac{1}{12}$, finding $\frac{1}{11}$ disturbing. There would then be $\frac{1}{12}$th of total hypermetropia; and, as $\frac{1}{24}$th had been found to be manifest, the other $\frac{1}{24}$th which was only revealed by the atropine would be called latent; the two quantities together ($\frac{1}{24} + \frac{1}{24} = \frac{1}{12}$) going to make up the total. It is always uncertain, prior to the action of atropine, how much hypermetropia the ciliary muscle may render latent; but it follows, from the progressive failure of accommodation as life advances, that the latent portion must undergo a corresponding decrease, and the manifest portion a corresponding increase. In young subjects, even a high degree of hypermetropia may all be rendered latent, so that the weakest convex glass is repudiated by the patient; while, towards the decline of life, even so low a degree as $\frac{1}{30}$th or $\frac{1}{40}$th will become manifest, and will render spectacles of equivalent power an assistance to distant vision. If hypermetropia is insufficiently corrected by glasses, the relief afforded will be only temporary, and the old troubles will recur after a longer or shorter period; so that it is always prudent and desirable to ascertain the total degree once for all, and to prescribe with reference to it from the first.[1] The effectual use of atropine implies the loss of reading power for four or five days, and sometimes for nearly twice that time; so that in adults it is usually best to examine the eyes singly, and to allow the one first tested to regain its power of accommodation before atropine is applied to the other. If a patient is leaving the neighborhood, or if from any other cause it is necessary to complete the examination without delay, both eyes must be taken together; but the nature of the application should in every case be explained before it is made, so that the effects of the temporary loss of accommodation may not occasion anxiety. It is not wholly superfluous to give a caution against applying atropine accidentally; for I have more than once seen great alarm occasioned in this manner, and I was once called upon to go several miles to a lady who was suffering from slight irritation of the eyelids, for which she had that morning visited another ophthalmic surgeon. She told me that this gentleman "had blinded her;" but I found nothing worse the matter than the action of atropine, and it turned out that he had wetted his fingers with a four-grain solution in using it for another person, and had then conveyed it unintentionally to the conjunctiva of the lady who next entered his room.

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[1] [It is sometimes essential, to determine at the outset the degree of the latent hypermetropia by actual measurement under atropia, but it is quite sufficient, in most cases, to measure the manifest hypermetropia only, and to base the first prescription of convex glasses upon this. If in any case we decide to use atropia for purposes of diagnosis in a hypermetropic person, we should ordinarily provide him with a pair of strong convex glasses, to use during the interval of temporary disability.]

With patients who are intelligent, and who act in good faith, the most trustworthy test of the degree of hypermetropia is their own statement that their distant vision is most aided by such or such a lens. But it sometimes happens, especially with stupid people or young children, that no definite statement can be obtained; and it is sometimes desirable to have the power of checking even a perfectly definite statement by other means. Within certain limitations, this power is afforded by the erect ophthalmoscopic image. The rays of light which leave a hypermetropic eye are divergent to an extent governed by the degree of its hypermetropia; and an emmetropic eye, with its accommodation suspended, can only obtain a clear image from parallel rays. A convex lens, which renders the divergent rays parallel will measure the degree of the hypermetropia, and will enable an emmetropic observer, with his accommodation at rest, to see every detail of the fundus of the hypermetropic eye. The best position for this convex lens is behind the mirror aperture; and it may be conveniently mounted with others in a Rekoss's disk, as in the ophthalmoscope of Loring (Fig. 32, page 99). Given an emmetropic observer with suspended accommodation, and he may read off the degree of hypermetropia in a few seconds, by finding the convex lens which gives him the best-defined erect image of the small vessels in the vicinity of the yellow spot. It does not do to take the optic disk as the point of sight for this purpose, because it is situated on the inner side of the posterior pole, and is therefore in a region which is a little nearer to the spectator, and consequently more hypermetropic, than the actual centre of vision.[1] If the observer is not emmetropic he may arrive at an equally certain result, his accommodation being suspended, by adding the known degree of his own myopia to the convex lens which he finds necessary, or by subtracting from this the known degree of his own hypermetropia. Of course the result, in the natural state of the eye, will be only the manifest hypermetropia of the patient; and, in order to discover the total effect, atropine must be used precisely as for the ordinary subjective examination. It is true that the accommodation of the observed eye relaxes in some degree whilst its fundus is being examined with the ophthalmoscope, because this eye has then no definite object of sight; but the relaxation thus produced is never complete, and there are no means of measuring or even of estimating it.[2] Returning to the

[1] [The difference in the distance of the disk and of the macula is trifling in emmetropic, and still more so in hypermetropic, eyes; and, for the vertical vessels of the disk, there is a compensation in the relatively oblique position of the lens. The larger retinal vessels, in and near the disk, afford too coarse a test for accurate determinations, and are besides by no means exactly on the same plane, or on that of the percipient elements of the retina.]

[2] ["In examinations with the ophthalmoscope [by the upright image] the total hypermetropia is revealed." (Mauthner, *Lehrbuch der Ophthalmoscopie*, 1, page 174.) "Without being able to accept, unreservedly, Mauthner's general statement that the total hypermetropia can be invariably determined by the ophthalmoscope [without atropia], we nevertheless believe that a very close approximation to it can

illustration already given, of hypermetropia = $\frac{1}{12}$, of which half is manifest and the rest latent, an emmetropic observer with suspended accommodation would require behind his mirror a convex lens of $\frac{1}{24}$, in order to see the fine vessels before atropine had been applied, and a convex lens of $\frac{1}{12}$ after its action had been fully produced. The facts of the refraction would then speak for themselves, and would be free from all complexity. If the observer himself is hypermetropic in the same degree as the patient, the intervening lens will have to correct the faults of both the eyes instead of the fault of one only; and hence, after atropine, a power of $\frac{1}{6}$ would be needed. From this the observer would deduct his own hypermetropia, = $\frac{1}{12}$, and would leave $\frac{1}{12}$ as that of the patient. If the observer is myopic to $\frac{1}{12}$, the two defects will neutralize one another, and a clear image will be obtained without any intervening lens. If the observer is myopic to $\frac{1}{24}$, he will require a convex lens of $\frac{1}{24}$, and the addition of these two quantities would bring out the same result.

The practical difficulty which impedes the application of this method is in the fulfilment of the essential condition that the accommodation of the observer must be suspended. In fact, this condition can only be completely fulfilled by the use of atropine; and the circumstances are rare under which a surgeon would think it necessary to cripple the usefulness of one of his own eyes for several days, in order to measure the refraction of a patient. Of course the method would be equally effectual if the accommodation of the observer could be exerted in some known degree; and there are persons of repute who allege that they are able to exert it in this manner. For my own part, I not only claim no such power, but am certain that I do not possess it; and I greatly doubt whether some of those who claim it do not deceive themselves. Being very slightly hypermetropic, I find that when I am looking into an emmetropic eye, through a weak concave lens, I can no more restrain my accommodation from unconsciously overcoming this lens than I can restrain the *besoin de respirer;* and, as long as the lens is well within the power of my ciliary muscle, the muscular sense is not sufficiently stimulated to call my attention to the effort. In the examination of hypermetropic eyes, my own accommodation unconsciously supplements the convex lens employed, and gives me a clear image while the correction is still insufficient; so that I underestimate the defect in an unknown and probably variable degree, and am compelled to regard my accommodation as an element of uncertainty which greatly detracts from the usefulness of the ophthalmoscope for hypermetropic cases. It enables me to say, in any case, that the degree of hypermetropia is at least so much, but it never enables me to say that the degree is so much and no more.[1]

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almost invariably be obtained." Loring, *Determination of the Refraction of the Eye by Means of the Ophthalmoscope.* New York, 1876.]

[1] [The power of relaxing the accommodation, at will, to some known constant quantity, may, we think, be acquired by most persons by practice. See note to page 100.]

In the illustrative case already given, in which $\frac{1}{24}$th of manifest hypermetropia is increased to $\frac{1}{12}$th of total hypermetropia by paralysis of the accommodation, it is obvious that the eye, with the addition of a twelve-inch convex lens, would be equivalent to an emmetropic eye. It would require no accommodation for distant objects; and the ordinary accommodation, according to their proximity, for near objects. At first sight, therefore, it would seem that spectacles which correct the total hypermetropia should remove all the inconveniences which it had occasioned. This view is only partially justified by experience; for the simple reason that the ciliary muscle, habituated from infancy to a certain degree of what may be called tonic spasm, returns to this state as soon as the effect of atropine has passed away, and cannot at first accept the fact that its constant services have been rendered superfluous. We are therefore in this dilemma, that if we correct only the manifest hypermetropia the symptoms will be only temporarily relieved; and, if we correct the total, we overcorrect for the actual state of vision, and obscure the distance, thus practically rendering the patient short-sighted. It is impossible,[1] of course, to maintain artificial relaxation of the ciliary muscle by atropine, because to do this would not only produce painful dazzling, and distortion of images by spherical aberration, but would also take away the power of accommodating for near objects. The only way out of the difficulty is to correct at first the whole of the manifest hypermetropia and only part of the total, and to increase the strength of the glasses at intervals, thus allowing the muscle to become relaxed gradually, and to adjust itself by degrees to the new conditions in which it is placed. In the case imagined, it would be judicious to begin the treatment by glasses of $+\frac{1}{18}$, which would correct the whole of the manifest and one-third of the latent hypermetropia; and, in all probability, glasses of $\frac{1}{12}$ might be taken into use after the lapse of a month or two. In still higher grades, such as $\frac{1}{9}$ or $\frac{1}{8}$, it is often necessary to arrive at complete correction by three or four stages, and it is seldom desirable to correct more than a fourth part of the latent hypermetropia at once.

Whatever glasses are prescribed, it is essential to the success of the treatment that they should be worn constantly, and should be regarded, so to speak, as essential parts of the eyes. When they are laid aside, even for a short time, the ciliary muscle returns to its old state of tonic contraction; and it will never relax into functional rest if it is subjected to sudden and violent alternations. The spectacles should be put on early in the morning, and should only be laid aside on getting into bed at night. During the first two or three weeks they are often irksome; and patients should be forewarned that they may be so, and that distant vision will be

[1] [Not impossible, but only inconvenient in most cases. In certain cases of hypermetropia with painful accommodation, Donders has shown that the best results can be attained only by the conjoint use, for a time, of atropia and strong convex glasses.]

obscured until the ciliary muscle has become relaxed in a degree equal to the amount of latent hypermetropia which has been corrected. The eyes are called upon to work under new conditions; and these, although more nearly physiological than those which preceded them, will be sources of discomfort until the novelty is set aside by custom. [In prescribing convex glasses for asthenopia dependent on hypermetropia, we prefer to give them, at first, of such power as may be found on trial to give relief and rest to the eyes. The greater comfort which even the occasional use of such glasses affords, soon leads to their being worn constantly, and a stronger pair will ordinarily be found acceptable in the course of a few weeks. A few changes of glasses, with regard to which instructions may, if necessary, be given in advance, thus suffice to enable the patient to use the eyes freely and with comfort, from the beginning of the treatment.]

There is no limit of age as regards the wearing of spectacles for hypermetropia; and they may be given to any child who is old enough to understand that they are not playthings. Practically, the asthenopia is seldom prominent until steady school-work is commenced. In cases of a mere tendency to squint, glasses will sometimes prevent this tendency from being developed; and they should almost always be worn after a squint operation, lest the continued action of the cause should induce a return of the deviation.

In the decline of life, hypermetropic eyes, like all others, become presbyopic, and, although fully corrected, they can no longer exert the accommodation necessary for reading. They then require, for this purpose, such an addition to the power in use as would be required by emmetropic eyes at the same period of life. A patient with total hypermetropia of $\frac{1}{12}$, wearing glasses of $+ \frac{1}{12}$, would require, at forty-five or fifty years of age, the addition of $+ \frac{1}{30}$ for reading. In other words, on settling himself to read, he would replace his glasses of $\frac{1}{12}$ by others of $\frac{1}{9}$ ($\frac{1}{12} + \frac{1}{30} = \frac{1}{9}$ nearly). On closing his book he would resume his usual power, which, for distant objects, would never require to be increased. It is often convenient to follow a plan which was devised by Benjamin Franklin, and to put together two half lenses in each ring of the spectacle frame; the upper half being the weaker, for distance, the lower half the stronger, for reading. French opticians have ground two powers upon the upper and lower portions of a single piece of glass; but the line of demarcation, in these lenses of two foci, is less accurately defined than by Franklin's original method. In the slight degrees of hypermetropia, such as $\frac{1}{30}$th or less, there is seldom any greater inconvenience than the early manifestation of presbyopia, until, at a period approaching old age, there is no longer [with parallel visual axes] a thirtieth of accommodation, and distant vision becomes dim. It may then be restored by wearing glasses of the low power required.

The most extreme form of hypermetropia is that which exists in eyes from which the crystalline lens has been removed, either by

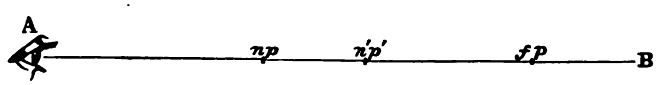
absorption after injury, or by operation for the cure of cataract. In these "aphakial" eyes, moreover, the faculty of accommodation is not only deficient but absent; and the patients require one power to afford clear vision of distant objects, and another, stronger than the first, for near objects, or for such pursuits as reading and needlework. The precise strength required for either purpose will vary with the original state of the refraction; but as a rule the glass for distant vision will range from + 3 to + 4½; and that for near vision from + 2 to + 2¾. For eyes originally myopic much lower powers are sufficient; and I have lately removed senile cataracts from a patient who has since read with + 5, and has walked about with + 11. The proper strength must in every case be determined by direct experiment, and the requisite trials should be deferred until the eyes have entirely recovered from the operation. On account of the weight of lenses of the necessary focal length it is desirable to have them of small size, and hence plano-convex lenses, scarcely larger than sixpences, are often used, and are mounted in circles of horn or tortoise shell, technically called "visuals," which fill up the space between the border of the lens and the ring of the spectacle frame. Notwithstanding the loss of accommodation, some patients who have been operated upon for cataract are able to see with tolerable distinctness at different ranges, while in others this power is wholly wanting. The difference appears to depend upon differences in the size and the contractility of the pupil; and persons of the latter class often experience difficulty, and at first even incur some danger, in descending steps, their reading glasses being too strong, and their glasses for distance too weak, to give them clear vision of the surface beneath their feet.[1] When such is the case, they should be advised to wear the glasses prescribed for distance, and to increase the power of these glasses, at times when a survey of the ground is desired, by drawing them some little distance down the nose.

The state of myopia, or short-sight, is a contrast to hypermetropia in all respects; alike in the physical formation upon which it is dependent, and in the functional conditions which it produces. In myopia, the antero-posterior axis of the eyeball is longer than the focal length of the refracting media; so that the focus of parallel rays is situated in front of the retina, and only divergent rays can be united upon its percipient layer. As the divergence of rays diminishes with the distance of the object, it follows that only near objects can be clearly seen; and the characteristic of myopia is that the "far-point," beyond which there is no defined vision, is situated at some near and measurable distance from the eye. The measure of this distance gives the degree of the myopia, and corresponds with the focal length of the concave lens by which

[1] [This uncertainty in walking, etc., after cataract extraction, depends largely upon the strong prismatic effect of the lower part of the glasses when the view is directed downward; the best remedy is to tip the glasses worn for walking a little forwards and to take care that they are set with their centres a little lower than the centres of the pupils.]

it may be corrected. Suppose, for example, that the far point is at twelve inches from the cornea; or, in other words, that rays of light, to afford clear vision, must be divergent from a point not more than twelve inches distant. A concave lens of twelve inches focal length imparts to parallel rays a divergence as if they proceeded from a point twelve inches distant, and consequently neutralizes or corrects the supposed degree of myopia, and renders remote objects plainly visible. The myopic eye, when passive, has clear vision only at its far point; but within this a certain range, limited, like that of normal eyes, by the near point, is conferred upon it by accommodation. The eye imagined, with myopia $= \frac{1}{12}$, if it had also accommodation $= \frac{1}{12}$, would have its near point at six inches distance; and the space between six inches and twelve inches would represent its sphere of functional activity, or the entire range of its vision. These conditions are shown in the diagram Fig. 111, in which A represents a myopic eye, looking along

FIG. 111.



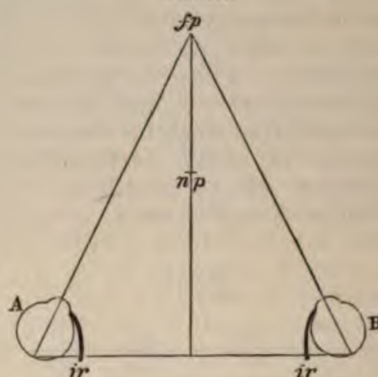
the line A B. When at rest, it sees clearly an object at the far point, *fp*; and by the exercise of accommodation it can see clearly objects which are nearer, until they arrive at the near point, *np*. Nearer than *np*, and beyond *fp*, it has no distinct vision except by optical assistance. The myopic eye, like all others, becomes the subject of presbyopia as life advances. Its power of accommodation diminishes, and its near point recedes, say to *n'p'*. It is not uncommon to hear an elderly person say, "I am not so short-sighted as I was;" and the belief that short-sight diminishes with increasing age is very widely spread. As a rule, this belief has no better foundation than the change above mentioned. The elderly myope has simply lost the nearer extremity of his range of vision. When young, he could see objects clearly at *np*, six inches from his cornea; and, when old, he cannot see them clearly if they are within the presbyopic or receded near point *n'p'*, which is, perhaps, eight inches from his cornea. The test of the degree of myopia is not the distance of the near point, but that of the far point, *fp*; and this latter distance, although it often undergoes diminution, never, as far as I am aware, undergoes increase.[1] We may always be well satisfied when the position of *fp* remains stationary.

The muscular conditions of myopic vision are that the converg-

[1] [This is quite true of the higher grades of myopia, but there can be but little doubt that in very low grades the senile changes described by Donders under the name of "hypermetropia acquisita," sometimes may exceed in degree, and so may neutralize, the pre-existing myopia. The point is not, however, of much practical importance.]

ence required is in excess of the accommodation. With a far point at twelve inches, the optic axes are convergent to this extent at least, the accommodation being then passive; and it is only when an object is brought still nearer that the accommodation is exerted as well as the convergence. In Fig. 112 the two myopic eyes A B are directed to their far point, *fp*, by a considerable exercise of

FIG. 112.



their internal recti muscles *ir;* but their accommodation may be still passive, and need not come into play until more convergence power is exerted, in order to direct them to *np*, or to some point intermediate between *fp* and *np*. As a rule, to which almost the only exceptions are when the light is defective or the object very minute, it is in every way more convenient to hold or place an object of vision at eleven or twelve inches from the eyes than at six or seven inches; and hence persons with a high degree of myopia have only a restricted demand for their accommodation, which faculty, moreover, either from disuse or from original formation, they often possess only in a restricted degree. Generally speaking, the higher the grade of the myopia, or the nearer the far point to the eye, the smaller will be the power of accommodation.

Myopic eyes possess certain visual advantages, which may be summed up by saying that they represent ordinary eyes to which convex lenses equivalent to the degree of the myopia have been added. They can discern a smaller object than others, and can read by a light which would be insufficient for others. The reason of this is that the light reflected from any object varies inversely as the square of the distance of the object; and hence a person who can bring a minute dot, or a printed page, to a near point only six inches distant, receives four times as much light from it as one whose near point is at twelve inches. Again, supposing the eyes to escape disease, a myopic person whose far point is within eighteen inches will escape the requirement of spectacles for the relief of presbyopia. Presbyopia will occur, but it can

never push back his near point quite to his far point, and hence it will never prevent him from reading at a convenient distance. When we hear wonderful stories of very aged persons who can "read without spectacles," we may at once conclude that such persons are not exceptions to the order of nature, but simply short-sighted people, whose eyes have been well preserved. They suffer, of course, at the other end of the scale, by requiring spectacles for the horizon.

To set against these doubtful advantages, doubtful because they only confer the power of doing, without a magnifying-glass, what everybody can do with one, there are many disadvantages which are not doubtful. From their power of discerning small objects, it is popularly believed that short-sighted eyes are "strong" eyes; but, in reality, they are very weak ones, and are more prone than any others to morbid changes of a serious kind. Besides this, the limited range of their vision is alone an evil of no small magnitude. Young persons who are short-sighted, and who are suffered to grow up without spectacles, that is to say, with no distinct vision of anything which is more than six inches or twelve inches from their noses, lose an amount of unconscious education which no teaching can supply. Their faculty of observation, in its wide sense, can at best be only partially developed, and their mental horizon is apt to be as contracted as their physical one. Even without reference to other equally important considerations, I am accustomed to urge upon parents that short-sighted children should be made to wear spectacles habitually, in order that they may see the world as it is, and may not people a world of their own with introspective and morbid imaginings.

The physical cause of myopia is elongation of the eyeball, but this elongation, instead of being an affair of symmetrical development, generally occurs at the expense of the posterior hemisphere, and implies some want of firmness of this portion of the ocular tunics. When eyes which are in this sense weak are kept in a condition of almost constant convergence, it is manifest that the pull of the internal recti muscles on their points of attachment (see Fig. 112) must produce a tendency to projection or bulging at the posterior pole of the eyeball, and consequently, a mechanical increase of the myopia.[1] The tunics which are thus perpetually stretched will in time become thinned and wasted in the region of least resistance; and this degenerative process, once originated, is apt to proceed rapidly. Accordingly, when myopic children first begin to read and to apply their eyes closely, we find that the degree of their myopia soon increases. After a time the ophthalmoscope shows a crescent of choroidal atrophy on one [the outer] side of the optic disk; and this crescent often enlarges to form a

[1] [The excessive convergence necessitated by the higher grades of myopia is doubtless an important element in determining a progressive tendency, but the explanation of its action is not so simple as that given in the text. Excessive convergence evokes excessive accommodation, and this by increasing intraocular tension may eventually lead to actual stretching of the sclera.]

broad annulus around the nerve. Behind the wasted choroid the sclerotic itself is thinned and projected backwards; and these disturbances, which tend to produce chronic inflammatory changes in all the parts concerned in them, lead, not unfrequently, to detachment of the retina and loss of sight. As a general rule, therefore, whenever the far point is near enough to require a dangerous degree of convergence, say whenever it is within twelve inches of the eyes, the patient should be made to read in glasses which will keep the far point at least twelve inches away. The use of such glasses is not at all to assist vision, but simply to prevent too much convergence, and thereby to prevent also the progressive increase of the myopia.

In some instances the troubles incidental to myopia are almost entirely muscular, and depend upon what is called insufficiency of the internal recti, or want of power to maintain the degree of convergence required for vision at the short distance at which alone it is possible. In such cases there is often much distress, much circumorbital pain or general headache, often supposed to be of a neuralgic character; and the incapacity to apply the eyes to work often reacts injuriously upon the spirits and the general health. I shall presently relate an example of the simulation, by this muscular insufficiency, of disease of a serious and alarming character.

The degree of myopia can in most cases be determined without the aid of atropine, and without any preparation of the eye.[1] It may be approximately estimated by the distance of the far point for small print. If a patient can read this at twelve inches, but not when it is further away, his myopia will be $= \frac{1}{12}$, or nearly so; and the surgeon would then try whether the best distant vision was given by a concave lens of $\frac{1}{12}$, or by one of $\frac{1}{11}$ or $\frac{1}{13}$. If $\frac{1}{11}$ were preferred, the surgeon would try $\frac{1}{10}$, or if $\frac{1}{13}$ were preferred he would try also $\frac{1}{14}$, and so on, until he arrived at that which afforded the most satisfactory result, and which he would note down as expressing provisionally at least, the degree which it was his object to ascertain.

With the ophthalmoscope, the determination is equally easy. The existence of myopia is declared, in high degrees, by the circumstance that an inverted image can be obtained without the intervention of an object lens; and, in all degrees, when the object lens is employed, by the magnitude of the field, by the small apparent size of the optic disk, of the bloodvessels, and of other details; and, generally, by the "myopic" crescent or zone of choroidal atrophy. The degree of myopia is shown by the power of the weakest concave lens which, placed behind the mirror, will afford a clearly defined erect image; it being necessary, as in the

[1] [This statement needs qualification. In many cases of myopia there is more or less of persistent accommodative spasm which yields slowly even to atropia, hence it oftens happens that we considerably overestimate the degree of myopia in our first tests with glasses, and that a gradual diminution of the defect may be observed if we repeat the tests daily, or at intervals of several days, while the eyes are kept under the full influence of atropia.]

case of hypermetropia, to look at the region of the macula lutea, and not at the eccentrically situated optic disk. The lens thus found will also be that which will give the best distant vision to the patient, unless an error has been introduced into the observation by the refraction or accommodation of the observer. If the observer is himself short-sighted, he will require a lens to correct his own myopia as well as that of the patient, and he must therefore deduct his own degree from that which the lens declares. If the observer has myopia $= \frac{1}{12}$, and if he obtains a clear erect image with a lens of $- \frac{1}{8}$ behind the mirror, he must deduct $\frac{1}{12}$ from $\frac{1}{8}$, which will leave $\frac{1}{12}$ as the degree of myopia of the patient. If the observer is not myopic, he may use too strong a concave lens, and may overcome the superfluity, even unconsciously, by his own accommodation. This error may be avoided by bringing up the concave lenses in regular succession from the weak to the strong, and by fixing upon the first in this order, with which the desired result can be obtained. The degree being determined, we are furnished with a clue to the nature of the effects which the myopia is likely to produce, and with a guide to the principles which should underlie the treatment.

In myopia of moderate or small degree, such as $\frac{1}{36}$, $\frac{1}{30}$, or anything less than $\frac{1}{20}$, the defect will produce limitation of distant vision, but will have no great tendency to shorten the reading distance, or to produce dangerous convergence. In such a case the friends of a child should be warned to be on their guard against any inclination to bring the book too near to the eyes, and should be cautioned, on this account, never to permit reading by firelight, twilight, or other defective illumination. The degree of the myopia should be tested every few months; so that any tendency to progressive increase may be discovered. Spectacles for distant vision would not be needed during early childhood; but their use might be commenced with advantage, on account of the desirableness of seeing the world, before the period of adolescence or of puberty. For a young lady, hand-glasses to hold up when they were required would be sufficient.

In these slight cases, there is room for presbyopia to displace the near point to an inconvenient remoteness; and this inconvenience is chiefly felt by clergymen, public readers, and lecturers. I have often been consulted by elderly clergymen, who were myopic to about $\frac{1}{36}$, so that they could not clearly see their congregations, and, at the same time, were presbyopic to about $\frac{1}{24}$, so that they could only read at arm's length, and could not read at all without a strong light. The remedy for this condition is a pair of Franklin's spectacles (page 471), with the upper halves of the lenses concave, to afford distant vision when the eyes are raised, the lower halves convex, to enable the book to be brought within twelve or fifteen inches of the reader.

Whenever myopia is of a higher grade than $\frac{1}{20}$, or whenever it is progressively increasing, spectacles should be worn, as a matter of regular habit, with the least possible delay; and the only ques-

tion to be decided is whether a single pair will suffice, or whether different powers will be needed for different uses. The answer to this question will depend partly upon the grade of the myopia and partly upon the strength of the accommodation. The effect of a complete correction of myopia by a concave lens is to render the eye, *plus* the lens, emmetropic as regards parallel rays, and to call upon it for the same amount of accommodation, for reading purposes, which would be required from an eye originally emmetropic. But it has been said already that in high degrees of myopia the accommodation is almost always feeble, and the more so the higher the degree, so that in a great many instances the myopic person is rendered practically presbyopic by complete correction, and is either not able to read at all, or can only read by holding his book at an inconveniently great distance from his eyes. As a very general rule, we find that a patient whose myopia is less than $\frac{1}{10}$ will bear complete correction, and will have accommodation enough for all purposes until the presbyopic period of life is reached; but a myopia greater than $\frac{1}{10}$ will generally require two pairs of spectacles, one for distant vision, and one, somewhat weaker, for reading. In order to arrive at the weaker pair, we state the desired reading distance in inches, convert it into a fraction by placing unity as a numerator, and subtract this fraction from that which gives the power of the correcting lens.[1] Thus, if we wish a patient with myopia $= \frac{1}{6}$ to read at fourteen inches, we say $\frac{1}{6} - \frac{1}{14} = \frac{1}{10.5}$, and we give reading-glasses of $\frac{1}{10}$ or $\frac{1}{11}$. In practice, it will usually be found the best plan to prescribe the correcting lenses in the first instance, to forbid reading for a time until the eyes have become habituated to them, and then to test the accommodation by actual near work. If the patient gets on comfortably, nothing more will be needed; but if the eyes feel strained and ache, or if near vision with the spectacles is found to be impossible, then weaker glasses must be prescribed for this purpose only. Of course, when a patient employing complete correction has passed the middle period of life, he may require weaker reading-glasses on account of his presbyopia. He would have required convex reading-glasses if he had been originally emmetropic; and he may require that an equivalent for these reading-glasses should be deducted from the concavity of those which still serve him for the horizon. A person fifty years old, and emmetropic, will usually require convex reading-glasses of $\frac{1}{30}$. A person fifty years old, myopic to $\frac{1}{12}$, and habituated to complete correction for distance, would therefore require to have reading glasses of $-\frac{1}{12} + \frac{1}{30} = -\frac{1}{20}$; or, in other words, would require concave glasses of $\frac{1}{20}$, instead of his usual glasses of $\frac{1}{12}$, for near work. This change would be precisely equivalent to adding glasses of $+\frac{1}{30}$ to the eyes of the supposed emmetrope.

In prescribing correcting glasses for distance, and weaker glasses

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[1] [In cases in which the neutralizing concave glasses which serve for distant vision do not answer for reading, the reading glasses should be chosen by actual trial rather than by any fixed rule.]

for reading, it is necessary to make the patient understand the respective uses of the two. The former are contributory to comfort, convenience, and education—permitting the wearer to see the world as others see it; and they may be laid aside without risk of physical injury, or of any other penalty than the loss of the advantages which they are calculated to afford. The latter, on the contrary, are intended to prevent the further progress of the defect; and they cannot be discontinued, especially by studious persons, without danger. The harm does not always happen; but the danger is always there. In order that it may be avoided, the myopic must be warned to keep their books at a sufficient distance, to sit erect, and to avoid working by bad light, which necessarily tends to produce approximation of the object. Besides the injury done by excessive convergence of the eyes, the contracted chests and the stooping and congested heads of unspectacled myopic persons are themselves great evils In connection with the whole of this subject, the researches of Dr. Cohn, of Breslau, published in 1868, on the prevalence and increase of myopia in German schools, are of great interest and value. I gave a full abstract of these researches in the "Report on Ophthalmology" in the *Year-Book of the New Sydenham Society* for 1870; and, in September 1871, wrote of them as follows in an article contributed to the *Practitioner:*

"Even superficial observers have long been aware of the great prevalence of myopia in Germany; but Dr. Cohn, by his examination of 10,000 children, has proved that it increases progressively in the ascent from the elementary to the upper schools; not only as regards the percentage of myopes to other pupils, but also as regards the maximum and average grades of the defect. In searching for the causes by which the conditions thus discovered might be explained, Dr. Cohn found them to be mainly two in number. The first was deficient illumination, rendering it necessary that the children should approximate their eyes to the work in order to receive light enough from its surface; and the second, defective construction of school fittings, the seats and desks being so arranged as to bring about the same approximation. The most common fault was that the seats and desks were too low, and too far apart, for the stature of the pupils,—who, sitting on the edge of a bench, were constrained to lean forward over their work. The probable spread of education in the United Kingdom renders it very desirable that in this particular our School Boards should take warning by the experience of others, and should not suffer this evil to be repeated amongst ourselves."[1]

The cases in which the ill effects of myopia are due rather to the difficulty of maintaining convergence than to the effects which convergence produces, are met with chiefly between the grades of $\frac{1}{6}$ and $\frac{1}{4}$. The most remarkable instance of this kind which has fallen under my observation was in a young gentleman, an account

[1] [Myopia appears to be about as prevalent among school children in the United States as in Germany.—See *Proc. Am. Soc. Science Ass'n* for 1875.]

of whose case I read before the Clinical Society in the session of 1874–5. He was brought to me by his father, with the statement that he had some obscure and intractable brain disease, and with a request that I would make an ophthalmoscopic examination, in order to see whether it would throw any light upon the state of the cerebral circulation. On inquiring into the history of the case, I was told that the patient, eighteen months previously, had been in perfect health, and reading for honors at Oxford, with every hope and expectation of obtaining them. He was suddenly attacked by symptoms which an Oxford practitioner attributed to some affection of the brain, and he was advised to throw up his work and to leave the University. At home, the advice thus given was confirmed; and it was also confirmed, shortly afterwards, by an eminent London physician, who prescribed a long period of complete brain rest, and a voyage to Australia as the best means of obtaining it. The patient actually went to Australia, and returned no better. He was then told that he must abandon the idea of succeeding to his father's large commercial undertakings, and that he must also abandon a marriage engagement which he had contracted prior to his breakdown. In other words, his prospects in life were blighted; and his despondency was commensurate with his misfortunes.

On inquiring further, I found that the so-called brain symptoms resolved themselves into inability to read. The memory and intelligence were perfect, and the general health was good; but after a short period of reading the letters and words became misty, and the mistiness was followed by vertigo. Perseverance in the effort produced palpitation of the heart, headache, and occasional sickness. Vision was perfect, but there was myopia, $= \frac{1}{8}$, of both eyes, and spectacles had never been worn for any purpose. With these data, the nature of the case seemed clear. My inference was that the patient had been accustomed to read somewhat within his far point, say at seven inches, and that his convergence power had enabled him to do this, without noticeable inconvenience, up to a certain time. When he began to read for honors, and hence to read continuously for long periods, the strain on the internal recti became too great, and they were unable to continue the effort demanded from them. The consequent relaxation of convergence produced double vision, in which, if the two images did not become distinct, they crossed one another in such a way as to confuse the outlines of the words, and were sufficient to occasion vertigo. The grave view taken of the case by medical authority brought in a new element of depressing emotion, which reacted upon the heart, disturbed the general cerebral circulation, and produced headache and sickness. When the attempt to read was repeated, the old symptoms were re-excited by the combined effect of the muscular sense and of expectant attention,—and so the malady was maintained. I assured the patient that his supposed brain disease was all moonshine, and prescribed for him two pairs of concave spectacles, one of $\frac{1}{8}$, for ordinary constant wear, one of

$\frac{1}{14}$, for reading at fourteen inches;—telling him at once to begin reading for half an hour at a time three times a day, and never to let his book come nearer than the prescribed distance. He called on me three weeks later to report that he was quite well, and that he was about to engage both in matrimony and in business. Since then nearly two years have elapsed, and I have had the satisfaction of hearing that the cure has been permanent.

Such a condition as the foregoing, although exceptional in the character of the resulting symptoms, is in no way exceptional in its essential nature. It belongs to a large order in which the derangement of muscular action assumes the form of insufficiency of the internal recti muscles, and in which the convergence effort necessary to afford single vision with both eyes cannot be maintained for any length of time. In such cases, nevertheless, an endeavor to maintain it will generally be made, and hence the use of the eyes will soon become irksome or painful. In too many instances, the pain has led persons imperfectly acquainted with the conditions to give advice to "rest the eyes;" advice which is in harmony with the natural inclinations of the patient, and which, when followed, affords temporary relief. If the muscles are not exerted they cease to ache. But, like all other muscles, they undergo loss of tone from disuse; and the more the eyes are rested the less they will be able to work. The common prescription of rest is altogether bad; unsound in principle, and disastrous in practice. I have seen many patients who have acted upon it sedulously; with the result that ten minutes' use of the eyes would at any time bring on pain and lacrymation; and that the unfortunate sufferers, debarred from nearly every form of intellectual occupation or amusement, were constantly dwelling upon their own defective vision, and upon their very natural fears lest blindness might some day close the scene.

The principle to be adopted in the management of such cases is to fix upon some practicable degree of convergence, say to twelve or fourteen inches, and then to train the muscles, by discreet and proper use, and by gymnastic exercises, to do what is required of them. For this purpose the first thing necessary is to choose the concave lenses which will afford the best vision at the selected distance. If the myopia is $= \frac{1}{7}$, and the selected distance is fourteen inches, we deduct $\frac{1}{14}$ from $\frac{1}{7}$. The remainder is $\frac{1}{14}$; and hence concave lenses of 14 inches focal length should be chosen. Their first effect will be to render the rays from an object fourteen inches distant as divergent as if its distance were only seven inches; so that these rays will be united upon the retina without accommodation effort. Experience must then determine whether the convergence to fourteen inches in repose of the accommodation is practicable or not; and if not, why not? It may be impracticable for various reasons—either from insufficiency of the internal recti muscles *per se*, or from the difficulty of keeping them in action while the accommodation is in repose, or from the fact that the accustomed convergence to seven inches has produced shortening

of the internal recti, with corresponding elongation and weakening of their opponents—so that vision at fourteen inches really requires a divergence effort, to which the external recti are unequal. In order to determine which of these conditions is present, it is necessary to be provided with a testing frame in which any desired pair of prisms can be placed before any pair of lenses, and rotated into any position without interfering with the latter. Such a frame, with the addition of a slide by which the distance apart of the lenses can be adjusted to fit any width of face, may be obtained from most instrument makers or opticians. The patient should first wear the concave lenses alone, and should read with them at fourteen inches until fatigue commences. A pair of weak prisms should then be added, say of about 4°, with their bases inwards. This arrangement will require the direction of the eyes to a more distant point; and, if the internal recti are tired of maintaining convergence, will give immediate, though perhaps only temporary relief. If, on the contrary, the internal recti are striving to bring the eyes to greater convergence, and the external recti are tired of resisting them, the prisms in this position will increase the strain, and may even produce double vision. By turning them round, so as to place their bases outwards, relief will be afforded. Relief by prisms with their bases outwards means weakness of the external recti. Relief by prisms with their bases inwards means weakness of the internal recti. In the latter case, the next point to be determined is whether the internal recti are weak absolutely, or only incapable of continued action during repose of the accommodation. To determine this, a trial should be made, after a period of rest, to see what strength of prism either internal rectus can overcome singly, so as to prevent the formation of double images. For this purpose a prism with its base outwards should be placed before one eye, and its strength increased until the double images of a candle flame six feet distant can no longer be united by muscular effort. If each internal rectus can overcome a prism of 12°, the muscles may be regarded as not absolutely inefficient; and then the proper treatment is to relax the accommodation by the regular use of atropine, and to persevere in reading with the prescribed lenses, and at the stated distance, until the difficulty is overcome. Such perseverance must be regarded and practiced as a gymnastic exercise, to be stopped before it produces undue fatigue, and to be resumed at regular intervals. There will often be a good deal of pain and trouble at first, especially with nervous patients, and with those who have previously been encouraged to "rest the eyes;" but the eventual reward is sure. If, on the other hand, the internal recti are absolutely weak, and cannot overcome the diplopia caused by a prism of 12°, it will usually be necessary to weaken their antagonists, by tenotomy of one or both external recti. After this operation, and, in some cases, even before it is performed, gymnastic exercises with prisms may be employed. For these, it is best to have two pairs of concave lenses of the proper focal length, ground on prisms of about

4°, and to have one pair mounted in a frame with bases inwards, the other with bases outwards. They may then be used for short periods alternately, the pair with bases outwards to call the internal recti into vigorous action, the pair with bases inwards to relax and rest the internal recti in the intervals of exertion.

In the very high degrees of myopia, ranging from $\frac{1}{6}$ up to $\frac{1}{3}$, or even to $\frac{1}{2}$, the principles of treatment are the same. But in these cases it often happens that the eyes have saved themselves from convergence strain at the expense of binocular vision; that is to say, they squint divergently with regard to objects at the visual distance of the patient. When this is so, and has become a confirmed habit, it will seldom be worth while to attempt to restore binocular vision. It will usually be found that one eye is used chiefly for reading, and the other [perhaps], with its appropriate glass, chiefly for distant vision. It can seldom be necessary to disturb such an arrangement; and the use of a glass for the reading eye is a matter which may be left to the instincts of the patient. He should be warned, however, if he does not use a glass, but prefers to bring his book close, that he should also hold it a little towards the side of the eye that is in use, instead of in the middle line of the face. The object of this is to rest all the muscles, by keeping the eye nearly in mid-position in the orbit.

In these cases of extreme myopia, it will often happen that the correcting lens gives only very imperfect distant vision. A lens of $-\frac{1}{2}$, or even of $-\frac{1}{3}$, produces so much divergence of the rays of light that only a small proportion of those which pass through it will enter a pupil of ordinary diameter. It also causes the formation of very small retinal images; and for both these reasons it usually fails to raise V. even nearly to the normal standard. A much better result is frequently afforded by one of the "cones" made by Steinheil of Munich, which can be obtained in London of Messrs. Carpenter & Westley. These cones are, in fact, small solid Galilean telescopes. They are about an inch in length, convex on the base, truncated and deeply concave at the apex. The convex base collects together a large amount of the light coming from a distant object; and the smaller concave summit renders this light sufficiently divergent for the degree of myopia for which each cone is adapted. The cones are covered with leather or shagreen; and are fitted with rings, by means of which they can be attached to a guard or watch-chain.

Precisely as, in hypermetropia, the accommodation which is required for vision brings in its train an unnecessary and disturbing element of convergence, so it will sometimes happen that in myopia the convergence which is necessary for vision brings in its train an unnecessary and disturbing element of accommodation. Especially in the higher degrees of myopia, when proper spectacles have not been worn habitually, we often find persistent spasm of the accommodation, which is precisely analogous to the persistent spasm of the internal recti which forms the basis of ordinary squint. Spasm of the accommodation increases, of course, the

apparent degree of the myopia, and it also tends directly to promote its progressive actual increase; besides being itself a source of pain or weariness in using the eyes. Whenever, in a high degree of myopia, such pain or weariness is complained of, or whenever the degree of myopia is increasing, this degree, after being first ascertained in the ordinary way, should be ascertained again when the eyes have been brought thoroughly under the influence of atropine. If spasm exists, it will be found that the real myopia of the atropinized eye is distinctly less than the apparent myopia of the same eye prior to the use of atropine; and, when this is the case, the spectacles must be prescribed with reference only to the real degree of the defect, and the return of spasm must be prevented by maintaining the action of atropine for some weeks, and until the use of the proper lenses has become habitual. It is not necessary, in order to maintain the effect of atropine when it has once been produced, to continue the employment of the ordinary four-grain solution. A drop of a solution of half a grain to the ounce, applied once in twenty-four hours, will generally be found sufficient for the purpose.

[Muscular asthenopia in myopes, and the progressive tendency which at some period characterizes nearly every case of myopia, are subjects of sufficient importance to justify a few additional remarks. Both result, ordinarily, from the attempt to use the eyes continuously for fine work, at short distances, and often with the additional disadvantage of insufficient illumination. In such continuous near work both accommodation and convergence become overstrained, and accommodative spasm, hyperæmia, and finally distension of the globe follow. The vision becomes myopic, and the relation of the two adjustments of accommodation and convergence becomes deranged, so that the two functions are no longer harmoniously performed, the convergence requisite for single vision at any distance within the far point being in excess of the accommodation needed to give sharply defined retinal images. If the myopia is developed very gradually, harmony between accommodation and convergence may be practically maintained, through an equally gradual adaptation of each function to the new conditions under which it has to work, and in that case there will be no other disability than short-sightedness. In other cases the convergence necessary for single vision at any given distance leads to accommodative efforts in excess of what is required for seeing clearly at the same distance, and this excessive accommodation leads in turn to the formation of the habit of holding the book nearer; convergence is now increased to suit this new reading distance, and this again evokes increased accommodation, which leads in its turn to increased convergence, until at last the myopia may so increase that convergence for the point of clearest vision may become too difficult to be long maintained, and thus to all the evils of progressive myopia we have superadded muscular asthenopia, insufficiency of the recti interni, or divergent strabismus.

Accepting these views as substantially illustrating the origin and progress of myopia in a person originally emmetropic, the first indication in the treatment of any case of incipient shortsightedness is to prevent strain, and control spasm, of the accommodation. This we can do perfectly by the systematic instillation of atropia, at the same time correcting the vision for reading by prescribing such glasses (whether convex or concave) as shall accurately place the far point of the corrected eye at the selected reading distance of fourteen or fifteen inches. Under this treatment the degree of apparent myopia, as measured by tests with concave glasses, may undergo marked diminution, or the myopia may even disappear altogether, and, by keeping up the treatment for a sufficient period, the threatened myopia may be for a time (perhaps permanently) averted, and even an actually established myopia may be reduced to a lower grade.

In certain cases of established myopia the most conspicuous failure is on the part of the recti interni muscles, and the disability assumes the form of muscular asthenopia. In the effort to read, at or near the absolute far point of the eyes, it becomes necessary for the myope at one and the same time fully to relax his accommodation and strongly to exert his convergence. Thus the two adjustments of accommodation and convergence, which ordinarily are performed together and in corresponding measure, are wholly or in great part divorced from each other and become relatively antagonistic. In treating the conditions which grow out of this antagonism, two indications present themselves: we may endeavor to reconcile the antagonists, or we may sacrifice either one of them. The former of these indications is best fulfilled by giving concave glasses of such strength as shall restore the proper relation between the two functions; and these may be aided to a limited extent by decentration of the lenses, by grinding their concave surfaces upon the two surfaces of thin prisms, or, in some cases, by tenotomy of the recti externi. The latter indication, of sacrificing either the convergence or the accommodation, is often attained by the patient covering one eye and so letting it diverge relatively; or it may be attained at will by the surgeon, through the systematic employment of atropia. In the former case binocular vision is sacrificed; in the latter, all accommodative adjustments are suppressed, and the eyes are left under the exclusive dominion of the recti muscles. In conjunction with the daily instillation of atropia, glasses should be prescribed for the purpose of placing the corrected far point at a proper reading distance, and, if the recti interni are still weak, recourse may be had, in addition, to prisms, and in some cases to tenotomy of the recti externi. In prescribing prismatic glasses, it is generally best to give liberal aid to the weakened muscles in the beginning, with the view of giving them needed rest, and afterwards gradually to withdraw it in the hope of developing increased convergence power.

Decentration of the ordinary concave glasses produces, within

certain limits dependent upon the focus of the lens, precisely the same effect as the grinding of spherical surfaces upon prisms. If spherical lenses are mounted eccentrically in circular frames, the distance between the centres of the lenses may be varied at will by simply turning the glasses symmetrically in their settings.]

In any case of uncomplicated myopia or hypermetropia, the lens which measures and corrects the defect should also raise vision nearly to the normal standard; although, in order to test this in hypermetropia, while the pupil remains fully dilated, it may be necessary to use also a metal disk with a small central opening, in order to correct the irregular refraction of the marginal parts of the cornea or the crystalline lens. Whenever the lens which gives the best result leaves vision at not more than half or two-thirds of the normal standard, and especially when the patient cannot express any very decided preference for one lens over all others, astigmatism may be suspected and looked for; and, if not found, the defective vision will then probably be traceable to some faulty development or structural change in the retina or the refracting media. Astigmatism has been already explained to be a difference of curvature in different meridians of the eye, meridians which are always at right angles to each other, and, usually but not always, horizontal and vertical, or nearly so.[1] The seat of the faulty curvature may be in one of the surfaces of the crystalline lens, and even, it is said, in the tunics of the posterior hemisphere;[2] but, as a rule, it is in the cornea. The practical effect is that the state of refraction differs, and consequently the nature and acuteness of vision differ, for lines drawn in different directions. A patient may be in a much higher degree myopic, or hypermetropic, for a vertical line than for a horizontal one, or *vice versâ;* or he may be myopic for one and hypermetropic for the

[1] [Of 477 astigmatic eyes tabulated by Snellen (*Archiv für Ophthalmologie*, XV, II, pp. 199–207), the meridian of greatest curvature was:

Vertical	in 238, or 50 per cent.
Horizontal	in 43, or 9 "
Inclined	in 196, or 41 "

Of 256 persons with astigmatism, in whom the refractive condition of both eyes could be determined, the defect was binocular in 222, or 86.5 per cent.

Of the 222 binocular cases, the direction of the meridian of greatest refraction was symmetrical in the two eyes in 138, or 62 per cent.

Of the 138 symmetrical cases the meridian of greatest refraction was:

Vertical	in 84, or 61 per cent.
Horizontal	in 17, or 12 "
Inclined	in 37, or 27 "

Of 84 cases of binocular astigmatism set down as unsymmetrical in the two eyes, a few (15.5 per cent.) approximated to the law of symmetry, varying not more than 6°; others (21 per cent.) showed a tendency toward symmetry in the fact that the inclination of the meridians of greatest refraction was in opposite directions in the two eyes; the rest (63 per cent.) were absolutely unsymmetrical, presenting a deviation from the vertical or horizontal in one eye only, or to the same side of the vertical in both eyes.]

[2] [The theory that the seat of the faulty curvature which gives rise to astigmatic vision may be in the retina rather than in the refractive media is altogether unsound, and is based upon a misapprehension of the actual optical problem.]

other. The practical effect will be that the vertical and horizontal boundaries of an object of vision are seen, under the same accommodation, with different degrees of distinctness; and in order that they may be seen with the same degree of distinctness, they must be seen alternately, the accommodation being adjusted first for one and then for the other. In reading printed characters, for example, the eye cannot at the same time discern clearly the vertical and horizontal parts of such letters as m, n, and u; and is consequently called upon, instead of accommodating once for all for the distance of the page, to accommodate alternately for the

[Fig. 113.]

[Fig. 114.]

[Fig. 115.]

[Fig. 116.]

two aspects of every word.[1] The exertion of doing this soon becomes wearisome; and when the defect is present in a high degree, or when the power of accommodation is failing with advancing life, ultimately becomes impossible. Astigmatism therefore produces asthenopia, or painful fatigue of the eyes, together with greater impairment of vision than ever attends upon either myopia

[1] [It is more frequently the case that astigmatic persons are content to accommodate for some one aspect of the printed page, oftenest we think for the vertical limbs of the letters in reading ordinary type. (See *Am. Journ. Med. Sciences*, July, 1867, p. 84.) In reading music they accommodate, if they can, for the horizontal lines of the staff.]

or hypermetropia only. The asthenopia increases with age;[1] and the impairment of vision depends upon defective sight of the boundaries of objects in some one direction. A patient once disclosed to me the nature of his defect by saying that his sight suffered regular impairment at certain hours of the day. He took a distant turret clock as his test object; and he could see the hands plainly when they were approximately vertical, but scarcely at all when they were approximately horizontal. [See Figs. 114 and 116, copied from photographs of Figs. 113 and 115 taken by a camera rendered astigmatic by the addition of a weak cylindrical lens. The ametropic meridian in this case is the horizontal, which results in a spreading out of both lines and spots in the same direction; hence the vertical lines in Fig. 114 are ill-defined, while the horizontal lines are bright and sharp. So also the spots in Fig. 116 are seen to run together in the horizontal rows, while they are perfectly distinct from each other in the vertical rows. The test-diagrams shown in Figs. 117 to 124, are arranged upon the principle here illustrated.]

If we imagine the lateral margins of a cornea, exactly on the horizontal diameter, to be a little approximated, while the margins on the vertical diameter are left in their natural state, we shall have an astigmatic surface. The curvature from side to side will be sharper than that from above downwards, and the eye will be rendered myopic for vertical lines while it remains unchanged for such as are horizontal. The bowl of a spoon affords a familiar example of a surface of somewhat similar character.

An ordinary convex or concave lens is a portion of a spherical surface, and refracts equally in all directions all the light which falls upon it. A cylindrical lens, on the contrary, as its name implies, is a segment of a cylinder, and refracts light only to or from a line parallel with the axis of the cylinder. If we take a concave cylinder of proper curve, and place it, with its axis vertical, before the eye [with its horizontal meridian myopic] imagined in the last paragraph, it will neutralize the myopia for vertical lines, and will be only a piece of plane glass with regard to horizontal ones. A plano-convex cylinder held before the [normal] eye with its axis horizontal produces artificial myopia for horizontal lines, but scarcely affects the clearness of vertical lines. A plano-concave cylinder, with its axis vertical, renders the eye hypermetropic for vertical lines, but scarcely affects the clearness of horizontal lines. It follows that, when astigmatism produces myopia for lines of a given direction, we may correct it by a concave cylinder with its axis in the same direction. When it produces hypermetropia for lines of a given direction, we may correct it by a convex cylinder

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[1] [With advancing age, when accommodation becomes sluggish and is at last nearly lost, the maintenance of wearisome adjustments, and, still more, rapid changes of adjustment, become impossible, and so the asthenopia may gradually diminish by giving place to a state of acquiescence in defective visual perception.—See *Am. Journ. Med. Sciences*, July, 1867, p. 84.]

with its axis in the same direction. To turn the axis exactly the other way would double the defect; and the excellence of the result depends upon the correct position of the glass being given and maintained.

It is obvious that a person who is either myopic or hypermetropic—say for vertical lines, but who sees horizontal lines accurately—will also see the lateral or vertical boundaries of an object more or less obscurely, or will even altogether lose sight of them. The lateral boundaries of a square might thus be rendered dim, or the lateral as distinguished from the upper and lower portions of the circumference of a circle Besides this, there is an almost infinitely small alteration in the apparent shape of objects, which appear elongated in the direction for which the eye is hypermetropic, or shortened in the direction for which it is myopic. For example, to an eye hypermetropic for vertical lines, a circle would tend to appear as an ellipse with its major axis vertical; and a square as an oblong with height greater than its breadth. To an eye myopic for vertical lines, the major axis of the apparent ellipse, and the greater length of the apparent oblong, would both be in the horizontal direction. But in order that this alteration may be appreciable, a considerable distance must intervene between the distorting or astigmatic medium, and the screen on which the image is received (just as the distortion of a shadow is increased by the distance of the surface on which the shadow is cast). Between the cornea and the retina the distance is not sufficient to produce any distortion which the senses can reognize; and astigmatic people see squares and circles in the same shapes as their neighbors, although with some portion of outline less sharply defined than the rest. If we render an eye artificially astigmatic, by placing even a strong cylindrical lens close to the cornea, the alteration in the apparent shape of objects is barely recognizable. If we move the lens an inch away from the eye, the alteration is no longer doubtful; and if we move it six inches away, all outlines become conspicuously changed. In the astigmatic eye itself, however, nothing of the kind occurs; and Mr. Liebreich's lecture at the Royal Institution, in which he attributed the peculiarities of some of Turner's pictures to the astigmatism of the artist, was neither more nor less than an elaborate hoax. It was illustrated, if I remember rightly, by a magic-lantern image of one of the pictures treated of, and in this image the interposition of a cylindrical lens was made to shorten up the figures as they appeared on the screen; doing so, on the principle already laid down, by virtue of the distance between the latter and the distorting medium. An analogous effect would have been produced on Turner's retinæ, and might possibly have been transferred to his canvas, if his corneæ had been placed upon antennæ, and thus worn, so to speak, two or three inches in front of the rest of his eyes, but in no other conceivable manner. The most curious result of the whimsical experiment thus made upon public credulity was the discovery

that a large proportion of the audience appeared to believe that the learned lecturer was in earnest.[1]

There are many methods by which the presence of astigmatism may be discovered subjectively; but the best is that by means of Dr. Pray's test-types, of which a reduced copy is given on p. 67, and which may be procured, in a size fit to hang in a consulting room, from the Autotype Fine Art Company. The myopia or hypermetropia being first corrected as far as possible, the patient is told to look at the types from a distance of ten or twelve feet, with the eye under examination, the other being screened or covered. He must be cautioned to look at the sheet as one object, and not to single out any particular letter. He is then asked whether the black and white lines are equally conspicuous in all the letters; and if he answers in the affirmative there is no astigmatism. If he is astigmatic, he will name some letter in which the lines are more sharply defined than in any of the rest, and will say on inquiry that they are least defined in the companion letter, below or above the first, which has its stripes in the opposite direction. For example, if the stripes are most conspicuous in N, they will be least conspicuous in Z, and *vice versâ*. If they are most conspicuous in T, they will be least conspicuous in D, and so on of the rest. There are very few eyes to which the stripes will appear absolutely identical; and the apparent difference must be fairly well marked in order to justify a diagnosis of astigmatism as a cause of imperfection of sight. The directions of the lines, in the letters in which they are most and least distinct, will be those of the meridians of least and greatest curvature.

Objectively, astigmatism may be discovered by the ophthalmoscope. In the inverted image, the optic disk of an astigmatic eye appears elliptical, with its major axis in the meridian of least curvature In the erect image, there is unequal definition of the bloodvessels which proceed in different directions. This is best seen where two vessels of about equal size cross each other, or diverge from each other nearly at a right angle. If one of them is sharply defined while the other is obscure, the presence of astigmatism is not doubtful.

In order to test the degree of astigmatism, it is proper to lay aside the letters, and to use single lines. I employ for this purpose a simple contrivance which was made for me by Messrs Carpenter and Westley, and which is represented in Figs. 118 and 119.[2]

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[1] [From Liebreich's somewhat famous lecture, as printed in *Macmillan's Magazine*, it would appear that he attributes Turner's remarkable change of style in painting in great part at least to a change in his eyes, and he hints at *cataract* as the probable change in Turner's case. Similarly he explains the marked change in coloring which is seen in the later works of Mulready by another progressive lenticular change, viz.: the development of an amber-like coloration in the nucleus. Liebreich's views, as set forth in this lecture, though perhaps not always quite clearly set forth, are nevertheless both ingenious and suggestive; they do not appear to us in any degree to justify Mr. Carter's estimate of them.]

[2] [The contrivance described in the text is a reproduction from the editor's *test-diagrams* for the detection and measurement of astigmatism. (Toetslijnen tot bepaling van astigmatisme, door Dr. John Green. *Verslag Ned. Gasth. v. Oogl.*, No. 7,

It consists of a circular metal plate, nine inches in diameter, with a loop by which it can be suspended against a wall. Around the margin the figures of an ordinary clock face are painted in black upon a white ground; and within the circle of figures a second circular plate, six inches in diameter, turns freely on a concealed central pivot. The second plate is also painted white, and is crossed by three parallel black lines, separated by white inter-spaces equal in width to themselves. The lines are placed first in the direction in which they are seen best, and then in a direction at right angles to the former, and the refraction is tested by lenses in both positions in the ordinary way. The difference will be the measure of the astigmatism; and, consequently, will also be the measure of the cylindrical lens which is required for its correction.

In order to illustrate this by an example, let us suppose that a patient is myopic, dim-sighted, and uncertain about the lens which suits him best with ordinary test-types. With — $\frac{1}{10}$, however, he tells us that the lines in the N of Pray's test-types are fairly visible, while those of the Z are very indistinct. We direct his attention to the dial above described, and turn the inner plate to render the parallel lines horizontal, or corresponding in position with the stripes in the N. We find by trial that these lines are best seen through a lens of — $\frac{1}{12}$. We note down that there is horizontal myopia = $\frac{1}{12}$, and we turn the lines into the opposite or vertical direction. Here they are best seen through a lens of — $\frac{1}{8}$. We note that there is vertical myopia = $\frac{1}{8}$. By deducting $\frac{1}{12}$ from $\frac{1}{8}$ we obtain $\frac{1}{24}$, and we say that there is myopic astigmatism = $\frac{1}{24}$, with preponderance in the vertical direction. A concave cylindrical lens of twenty-four inches focal length, with its axis vertical, will restore the equilibrium between the two meridians; and will leave the whole eye with a myopia equal to $\frac{1}{12}$. We order the $\frac{1}{24}$ concave cylinder to be ground on one side of a lens, and a common concave $\frac{1}{12}$th on the other, and by this combination we correct both the myopia and the astigmatism as long as the axis of the cylinder is in the vertical position. To place it with the axis horizontal would be to double the astigmatism; and in any intermediate position it would do at least as much harm as good. Hypermetropic astigmatism is measured in the same way, but with convex instead of with concave lenses, and after the use of atropine. When, instead of being myopic or hypermetropic in both meridians, the eye is emmetropic in one, the spherical lens which corrects the refraction in the other is the measure of the astigmatism, and of the plano-cylinder by which it will be relieved. When the eye is myopic in one meridian and hypermetropic in the other,

1866. *Ned. Arch. v. Gen. en Natuurk.*, II, 1866 On the Detection and Measurement of Astigmatism, *Am. Journ. Med. Sciences*, January, 1867. On a New System of Tests for the Detection and Measurement of Astigmatism, *Trans. Am. Oph. Soc.* for 1867 and 1868.) The diagram adopted by the author is that shown in Fig. 118, mounted to turn upon the central pivot of the dial, Fig. 119. Figs. 117 to 119 are exact reductions from the three diagrams published in 1866; Figs. 120 to 124 are similar reductions from additional diagrams presented to the *Am. Oph. Soc.* at the meeting in 1867, and published in the *Transactions* for 1867 and 1868.]

the astigmatism is the sum of the two defects, and not their difference. Thus, if there were myopia for vertical lines = $\frac{1}{20}$, and hypermetropia for horizontal lines = $\frac{1}{24}$, the astigmatism would be equal to $\frac{1}{11}$ nearly, and would be corrected by a convex cylinder of $\frac{1}{11}$, with its axis horizontal. Whatever may be the degree of astigmatism, it should, for all purposes, be corrected as nearly as possible. When the astigmatism is corrected, the eye may still be presbyopic, myopic, or hypermetropic, and must be dealt with, in these regards, on the principles already laid down; one side of the lens being given to the cylindrical element, the other to the spherical element, in any glasses which may be necessary.

[The *test-diagrams* shown in Figs. 117 to 124 are designed to be used at a distance of from ten to twenty feet. The dial card, Fig. 119, is about fourteen inches square, and the circular cards, Figs. 117 to 121, are about nine and a half inches in diameter. The single black lines, as well as the white interspaces in Figs. 118, 119, and 121, are of the same width as the lines which make up the letters of No. XX of Snellen's *test-letters*, and should be seen distinctly at a distance of twenty Paris feet. In using these diagrams for the detection of astigmatism, we bring before the eye under examination a series of ordinary convex or concave glasses, until we arrive at the strongest convex or weakest concave glass through which any one of the sets of lines in Fig. 119, or of the radii or sectors in Fig. 117 or 120, is distinctly seen. The direction of this most distinctly seen radius or sector in Fig. 117 or 120, is the direction of the principal meridian of least refraction. For measuring the difference of refraction in the two principal meridians, of least and greatest refraction respectively, we first devised the test shown in Fig. 118, placing the card upon the dial and turning it successively in the direction of the two principal meridians, as determined by the trial with Fig. 117 or 120, but we prefer on the whole the diagram shown by Fig. 121, in which the two crossed sets of lines are set at the same time in the two principal meridians, and so serve for comparative observations during the trials which we proceed to make with concave cylindrical test-glasses. At present we rely oftenest, perhaps, upon the diagrams shown in Figs. 117 and 120, both for the detection of astigmatism and its measurement, but we have about a dozen, differing more or less in construction or arrangement, all of which are occasionally useful.

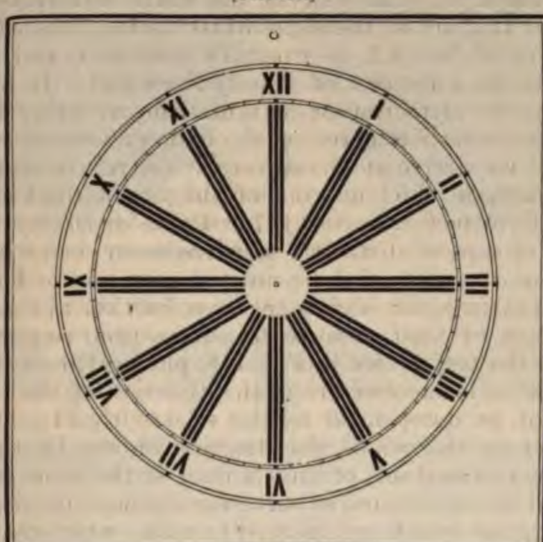
Fig. 124 is one of our older arrangements, in which the same degrees of inclination are given as in Fig. 119. Figs. 122 and 123 consist of narrow lines, and rows of holes, punched out of disks of blackened card-board, and covered on the back with fine tissue-paper, either white or colored; they are designed to be hung in a window and viewed as transparencies. By suspending these as well as the rectangular card, Fig. 124, from the small holes shown at the top of each, the degree of inclination of the several lines, sets of lines, and rows of spots, may be varied at pleasure.]

The degree of astigmatism, as well as its existence, may some-

[Fig. 117.]

[Fig. 118.]

[Fig. 119.]



[Fig. 120.]

[Fig. 121.]

times be determined by the opthalmoscope with a near approach to accuracy. I have several times arrived at a very fair result in myopic cases; but I cannot exclude errors due to my own accommodation in examining the hypermetropic. Experience has taught me, moreover, to distrust the ophthalmoscope when it is employed for this purpose by others, and hence I do not think it necessary to enter into details about its application. I have already had occasion to say that London consultants enjoy great opportunities of learning humility from the errors of their neighbors; and I have seen quite a considerable number of patients whose astigmatism has been ophthalmoscopically tested by surgeons who rely upon this method, and who have prescribed spectacles which had the single fault that they failed to improve the sight of the wearers.[1]

Although astigmatism is generally a natural malformation, it is by no means unknown as an artificial one; in which form it is liable to occur after iridectomy or after cataract extraction. If the cicatrix left in either case should be broader than a mere line, it can hardly fail to modify the corneal curvature at right angles to its own track; and I have seen several instances in which vision after an operation was seemingly much impaired, but was raised nearly to the normal standard by the detection and relief of artificial astigmatism. In these cases, too, it is sometimes better for certain purposes to complement the astigmatism than to correct it. I once performed iridectomy, for serous iritis, on a gentleman forty years of age, who made a good recovery, but whose vision was still impaired when the eye seemed quite well. I found that he was emmetropic for horizontal lines, but that he had become myopic to $\frac{1}{24}$th for vertical ones. A concave plano-cylinder of $\frac{1}{24}$, with its axis vertical, restored normal vision for distant objects, but left him with feeble accommodation, and requiring reading-glasses on account of presbyopia, the advent of which had been hastened by the disease. So, instead of correcting his astigmatism, I completed it by giving him a convex plano-cylinder of $\frac{1}{24}$, with its axis horizontal. This rendered him equally myopic all round, and thus relieved his presbyopia. A spherical lens of $+\frac{1}{24}$ was put into the other ring of the spectacle frame, and with this assistance the patient was able to read "brilliant" type with either eye, and to combine the two images easily.

In all cases in which cylindrical glasses are required, it is better to have them in spectacle frames than in any kind of nose clip; because, in the former, they are more likely to retain their right position before the eyes. It is also better to have circular lenses than oval ones, because the position of the former can be regulated with great nicety, and can be altered at any time if they become displaced.[2] The little screw which fastens the spectacle frame on

[1] [The ophthalmoscope is often of the greatest use in determining the existence or non-existence of astigmatism, and there is no doubt that by means of Loring's instrument (Fig. 32, page 99) quite accurate measurements may be made by a practiced and careful observer. This method is, however, much less accurate than that by trials with glasses, and its results should be accepted as approximations only.]

[2] [There is no good reason for preferring circular lenses to the usual oval or ob-

the outer side can be loosened, and the glass turned in the ring to any extent which may be necessary. When astigmatism exists after a cataract operation, it may be relieved by a very ingenious American contrivance.[1] The necessary spherical lens should be made small and plano-convex, and then cemented to the plane face of the necessary plano cylinder. The spectacles thus constructed are neither heavy nor unsightly, and are a great improvement upon cylindrical cataract glasses made in any other manner.

[Fig. 122.]

[Fig. 123.]

[Fig. 124.]

As everything must have a name, and as there is a certain reasonableness in describing as "isometropia" the state in which both

long shape. If the oculist is competent he can prescribe the angle of inclination of the axis of the lenses with perfect accuracy, and a competent optician will find no difficulty in accurately executing the order. Circular lenses can, it is true, be readjusted if they become turned in their frames, but circular glasses alone are subject to such accidental displacement. For the past ten years we have habitually employed oval frames for cylindrical glasses, at first by giving some personal attention to the setting of them, but latterly by including all the elements of the case in a written prescription. Such prescriptions have been filled for us by Mr. H. W. Hunter, of New York, with unvarying accuracy.]

[1] [The invention of Dr. E. G. Loring, of New York, and executed by Hunter. (*Trans. Am. Oph. Soc.*, 1871.) The cement used is inspissated Canada balsam.]

eyes are alike in their refraction, some ingenious person has invented the word "anisometropia" to express the contrary condition. Anisometropia may be infinitely various in its character, but the most common form is that in which both eyes are myopic, or both hypermetropic, but in different degrees. In every case of the kind, each eye should be tested and examined singly, and then the correcting lenses required for each should be mounted in the same frame and used for a time experimentally. If good binocular vision can be obtained without discomfort, the differing lenses may be used together permanently. But if the dissimilar images formed on the two retinæ cannot be easily united, or if pain or sensations of straining in the eyes are produced, it will be better in either case to abandon any attempt at combination, and to consider chiefly the requirements of that eye from which the best and most useful vision can be obtained.

In all forms of ametropia, and even in some instances of presbyopia, but more especially in myopia, complaints are occasionally made of the presence of floating bodies which dance before the eyes, and which have received the name of "muscæ volitantes." These muscæ are often sources of considerable discomfort, not only from the way in which they engage the attention, but also from the fears which they excite. They are usually described as bearing a resemblance to beaded threads or filaments variously curved and disposed. They are most conspicuous when the eyes are turned towards a white surface, such as a whitewashed wall or ceiling, or a white cloud; and it is characteristic of them that they never cross the axis of vision, nor obscure or conceal the spot which is looked at, but move about over lateral portions of the field They are due to the shadows cast upon the retina by the minute objects in the vitreous body which have been described at page 42; and these shadows are more visible to myopic persons than to others, because in the former the greater length of the vitreous chamber allows a given object to cast upon the retina a shadow of larger size.[1] A temporary increase of muscæ may be occasioned by any conditions which disturb the balance of the ocular circulation, and thus alter the density and the index of refraction of the fluids within the eye.[2] Within certain limits they must be regarded as physiological phenomena, which require only to be neglected by the patient; but when they are either very

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[1] [It is only those motes in the vitreous which are near the retina that give rise to the ordinary perception of muscæ volitantes, for the reason that the shadows of objects situated far anterior to the retina are but faint and for the most part imperceptible penumbræ. To produce distinct shadows of the structures situated in the anterior region of the eyeball it is necessary to transmit an approximately homocentric and parallel pencil of light through the media. This is done by holding a card, in which a fine pinhole has been pricked, about half an inch in front of the eye, and looking through it at a bright cloud or at the ground-glass shade of a lamp. The explanation of the annoyance from muscæ which is frequently observed in myopia is to be sought in the fact that the shadows cast upon the retina are often the only clearly defined images present, and so compel attention to themselves.]

[2] [Muscæ appearing under these conditions are probably often dependent on a temporary increase of the structural elements present in the vitreous.]

abundant or steadily increasing, they may point to actual or impending morbid changes of a serious character; and they should lead, under such conditions, to a careful examination of the eyes, and also of the general state of the patient.

The materials of which spectacle lenses are made are two in number: crown glass and rock crystal, or, as it is commonly called, pebble. In former times, when the manufacture of glass was less perfectly conducted than at present, this material was liable to undergo chemical changes which diminished its transparency; so that glass lenses, after a certain period of wear, became dull and clouded. At that time, "pebbles" were held in high esteem; but, now that good glass is as permanently transparent as pebble itself, the latter no longer possesses the advantages which were once justly claimed for it. Pebble is still, however, harder than glass, so as to be less liable to scratches or accidental fracture; and it is also, for the same refractive power, less heavy and less bulky. Hence it is to be preferred, when the somewhat greater cost is not an obstacle, for convex lenses generally, for all lenses of high power, and for such as are likely to be worn for a long time without variation; whenever, in short, durability and lightness are important. For concave lenses, the recessed surfaces of which are little liable to injury, and for convex lenses used only for a temporary purpose, such, for instance, as the first partial correction of hypermetropia, glass will be found to fulfil every requirement. In one respect glass is even better than pebble; for the former is optically homogeneous, while the latter is in certain directions bi-refringent; that is to say, it splits a pencil of light into two portions, so as to form two images of the object from which it proceeds. On this account, the best pebble lenses are cut in planes perpendicular to the axis of double refraction; and, when this is accurately done, they are as optically homogeneous as glass itself. Inferior manufacturers, whose aim it is to obtain the largest possible number of lenses from a given piece of crystal, neglect this precaution, and cut their lenses any way, either obliquely to, or even parallel with, the bi-refringent axis. In the slight thickness of a spectacle lens, complete double refraction is never produced; but the outlines of objects may be rendered somewhat shadowy and ill-defined. In order to determine whether a pebble lens is correctly cut, it is only necessary to place it between two plates of selenite, and to look at the combination by transmitted light. If the lens is correctly cut, the color zones produced by polarization will be circles; if it is incorrectly cut, they will be more or less distorted and unsymmetrical. A ready means of distinguishing between a glass and a pebble lens is afforded by the fact that the latter is a much more ready conductor of heat than the former, and hence that it feels sensibly cold when touched by the tip of the tongue.

Whatever spectacles are required, the frame in which the lenses are mounted should be carefully suited to the facial conformation of the patient. The material employed is scarcely more than a

matter of taste; although, on the whole, steel may be said to combine the greatest number of advantages. For hot and moist climates, in which steel would be liable to rust, it is better to have gold or silver, or to have the steel gilded, or plated with silver or with nickel. The really important matter is that the frame should fit in such a manner that each eye may look through the centre of its corresponding lens. Any eccentric part of a lens is, in fact, a prism; and displaces the apparent position of an object seen through it. Such displacement, especially when it is in opposite directions for the two eyes, becomes a source of distress on account of the irregular muscular action by which alone the displaced images can be united or combined. When prismatic spectacles are necessary, they should be given in accordance with the principles already laid down; but never accidentally and irregularly, by carelessness in the selection of a frame. The optician should measure the distance between the pupils of the eyes by means of compasses; and should also so adjust the intermediate portion of the frame that the lenses may be supported at a proper level. Concave lenses, as a rule, should be barely clear of the extremities of the eyelashes; convex lenses, especially for presbyopia, may be worn some little distance down the nose. When required for hypermetropia, it is important that the patient should not look over them, and then they must be brought near enough to prevent this from being done. For people who object to spectacles, lenses are mounted in hand-frames, or in nose-clips, of all sorts and patterns; but a well-made spectacle frame is really the most comfortable, and by far the most convenient, of any arrangement which has been devised.

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ERRATA.

Page 18, line 6, *for* "lacrymalia" *read* "lachrymalia."
" 31, line 3 from bottom, *insert a period after* "partial."
" 32, lines 20 to 23, *for last sentence in brackets, substitute* "It appears probable that the two spaces sometimes communicate with each other through minute openings in the arachnoidal sheath. Schwalbe, *op. cit.*, I, I, pp. 329 to 334."
" 34, line 33, *for* "calabar" *read* "Calabar."
" 47, line 11, *for* "lacrymale" *read* "lachrymale."
" 50, line 7 from bottom, *insert a* colon *after* "surface."
" 56, line 4 of footnote, *dele* comma *after* "retinitis."
" 64, line 17, *for* "case" *read* "cases."
" 74, line 7 from bottom, *for* "Speciellen" *read* "speciellen."
" 76, line 12 of Chapter III, *insert a* period *after* "eye."
" 92, line 8 from bottom, *dele* bracket *after* "observer."
" 93, line 2, *insert a* colon *after* "distress."
" 93, line 8, *insert a* colon *after* "desired."
" 186, last line of footnote, *for* "59" *read* "58."
" 191, line 18, *for* "Jäsche Arlt" *read* "Jasche-Arlt."
" 204, line 32, *for* "Lawrence" *read* "Laurence."
" 210, lines 5 and 6, *for* "ij or v" *read* "ij to v."
" 228, line 8, *for* "X or XXX" *read* "X to XXX."
" 262, line 1 of footnote, *for* "transparent cornea" *read* "corneal margin."
" 266, line 4 of footnote, *for* "Soelberg-Wells" *read* "Soelberg Wells."
" 281, line 36, *for* "Lawrence" *read* "Laurence."
" 299, line 1 of second paragraph, for "*c la*" read "cela."
" 363, line 15, *insert reference sign* "[1]" *after* "dangerous."
" 438, line 20, *for* "strasbismus" *read* "strabismus."
" 458, line 3 from bottom in footnote, *for* "24" *read* "2.4."

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Contents of Monthly Abstract of Med. Science. July—Dec. 1875—(Continued.)

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